JOURNAL

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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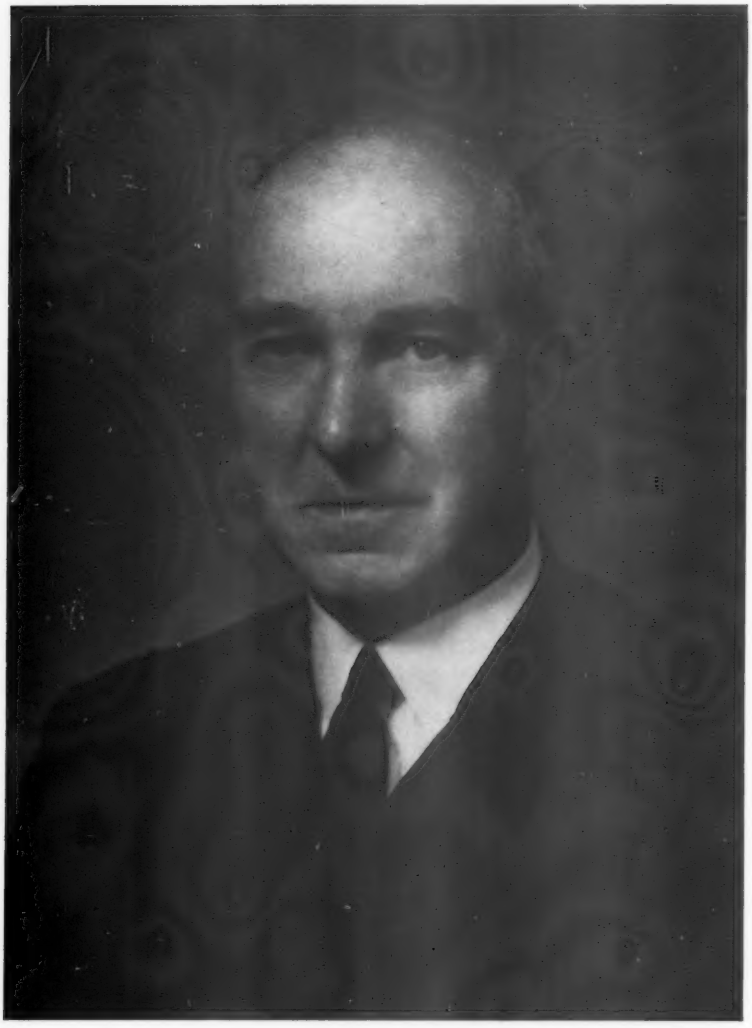

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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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METAMORPHOSIS

IT IS ALMOST A TRUISM THAT THE EDUCATED MAN TO-DAY has not the time for reading all he would like to. Probably it is more accurate to say that his reading falls into two groups: he finds time to read a proportion of what is useful to him in his work and in his understanding of public affairs, and he makes time to read everything he really wants to. Whether it is Jane Austen, *A Study of History*, *The Strength of Materials*, a Sunday newspaper or *The Caine Mutiny*, something that has temporarily entwined the branches of his mind will drain time from other occupations which, weighed against less engaging pursuits, he would have pronounced all important. The *Journal*, we suspect, has previously lain firmly in the first group of reading matter. It has, in any event, been largely a periodical of reference; the hard-pressed electrical engineer could satisfy his feeling of allegiance to The Institution by skimming through its pages, after it had ungrudgingly retained its cylindrical form for, perhaps, ten days on his desk. An impending journey to an Institution meeting, or a desire to read about a colleague's paper, would doubtless quicken greater interest in him.

It would be sanguine indeed to suggest that this new *Journal* will join the second group; we hope that some of its contents will do so, and that, freshly cooked and on a new dish, it will as a whole seem more appetizing. Not all members will like the new format, but it is believed that most will, and that none will find the *Journal* less readable than before. For the Council's aim has been "that there should be a publication common to all members of The Institution, which all would desire to read." Thus, although the *Journal* will still provide members with reference information on Institution activities, most of which will appear in smaller type towards the end of each issue, it will have also new features which are designed to illustrate and interpret the record of electrical progress in the *Proceedings*.

The Institution has never ceased to stress the unity of electrical engineering and the necessity for specialist electrical engineers to know something of what is happening in all branches of their profession. The Council intends that the new *Journal* shall help in keeping the 40 000 members of The Institution informed in this respect; the *Journal* will speak and, we trust, flourish on the common ground of all members.

One of the new features will be special articles on current Institution papers that have been accepted for reading. Appearing before the date of the relevant meeting, an article may serve to introduce the paper to members; often it will be published after a paper has been read and may include an account of the discussion, and, perhaps, some operating experience additional to that given in the paper. Sometimes an article written a year or so after a topical paper will follow up the subject so that members can know how it has progressed since the paper was read. Another feature will be the electrical engineering review, which will appear at intervals of a few months. This will normally cover in some detail a field narrower than that of the progress review which appears in the *Proceedings*, and, in the main, be fully intelligible to all electrical engineers, no matter what their speciality. A third feature, which we hope will be much used, is the correspondence page. There has been little outlet for the electrical engineering letter that has an aim similar to the scientific letters appearing regularly in *Nature*; the correspondence page of the *Journal* provides such an outlet. On a more domestic note, the new section entitled "News from Abroad" will try to do for members oversea what has previously been (and will continue to be) done for the Local Centres at home. This is surely important—one of the most cogent reasons for the existence of the *Journal* is the member, especially an oversea member, who can rarely come to an Institution meeting or social activity. Members abroad may wish to read primarily about events at home, but if it is to play any part, however small, in strengthening the world-wide ties of The Institution, news of this kind must be both *for* and *about* all the membership.

The first aim of the *Journal* must be to serve the needs of members, especially those of the professional electrical engineer, and although it will do this primarily by pivoting on Institution events, the *Journal* will not be shy to go outside their terrain on occasion. Thus there will sometimes be included a critical commentary on some engineering topic of general interest such as the leader on railway electrification that appears in this issue, and there will from time to time be articles on subjects such as law or economics which will be written to appeal to engineers. To-day the term "professional engineer" implies more than someone who professes a deep know-

ledge of science and technology. His knowledge is wide, embracing many other subjects. As reported elsewhere in this issue, the immediate Past-President has recently said, "There is a great job here for every engineer, to do his best to bring together the two sides of our civilization, the humanities and the sciences." The Institution's *Journal* will try to play its part in this.

Although we shall in the pages of this periodical be straying at times from Savoy Place we do not aim to enter the precincts of the technical Press. The Institution values greatly the service it receives from the major periodicals covering electrical engineering, and there must be very few members who do not regularly read one or more of these. To attempt to duplicate their work would be highly unnecessary, and there are indeed several fields, such as the commercial and proprietary, which the Royal Charter of The Institution precludes its *Journal* from cultivating. The *Journal* should surely be complementary to the technical Press, many of whose organs appear weekly; it is perhaps worth noting that there is no other British monthly devoted to the whole realm of electrical engineering.

A periodical of this kind does not take a new shape without much work by many people; we would pay a tribute to the printers, who, in the face of a serious labour shortage, have taken in their stride this first issue, with its comparative complication of make-up and its altered binding.

NINETEEN FIFTY-FIVE

TRADITIONALLY the advent of a New Year is a time for taking stock—for casting up a balance sheet of the past and making an assessment of the future. I think, if we are honest with ourselves, we shall admit that, in times of uncertainty, there is less tendency to take stock. The war years were examples of what I mean. Then we lived without too much thought for the morrow, and only the single purpose drove us on. To-day, we are in much better case. This is the first New Year's Day since 1939 that, officially, the whole world is at peace. Everywhere the flags are furled and the war drums cease to roll. We all rejoice that this is so and pray that it may long continue.

But what a commentary upon man's moral progress that all youths and maidens under sixteen have just experienced their first New Year's Day in a world at peace. Why is it that after a million years of evolutionary development in language, in art, in science—development that has made us lords of creation, has given us dominion over earth, sea and air, and has enabled us to encircle our planet during a long week-end—why is it that we still must resort so frequently and with increasing violence to the habits of the jungle in the settlement of our disputes?

The fact that force has always been the ultimate arbiter is understandable, for, in the absence of impartial law accepted and honoured by all parties, what other method is there? Unless the rule of law is observed internationally as fully as is the law administered by our own courts of justice, there is little hope of abolishing war. First, there must be a valid code of international law that commands general acceptance, and it must be backed by sufficient force—moral and physical—to ensure its observance. Even this is a tacit acceptance that force is the ultimate arbiter.

But what concerns us in practice is not that force must be available but how often and how devastatingly it has to be used. This will be determined by the natural justice of the international legal code, by the removal of the sense of injustice under which any nation, creed or class labours in real day-to-day life, by the emergence of a personal attitude less sensitive to fancied wrongs, and by a spirit of live and let live in striving for sectional betterment.

We, who are members of a large and growing profession, can and should use our full influence in the establishment of just international law. We must not think that, because our profession deals primarily with *things*, we are in any way absolved from the duty to do all in our power for the welfare and good government of *people*. If all else in this message is forgotten, let it be remembered that we are part of the human family first and scientists second. We, perhaps more than most, are in a position to apprehend and value the need for laws that stand the test of experience. Let us continue to strive for just that kind of law in human affairs.

The other criteria are also important. A sense of injustice is often removed by an improvement in standard of living, and who are better placed than scientists and engineers to improve the standards of physical well-being throughout the world? Already we have done much in the well-developed countries; let us do likewise for the backward places. Thus, with greater equality of opportunity and the means to use it beneficially, we shall at least have provided the conditions in which man can adopt a less sensitive approach to fancied wrongs and a live-and-let-live attitude in striving for further sectional betterment.

Whether man will respond depends on his spiritual development. It may take a long time. But, with the rule of law generally recognized and backed by adequate force in a well-ordered physical world, the chances of prolonged peace should, indeed, be better than they seem at present.

As an Institution we played our full part last year in the causes of international harmony and of better education at home. This is a continuing process, and I trust that, with your help, 1955 will be equally fruitful.

May it be so for you all.

PRESIDENT

RAILWAY ELECTRIFICATION

By **The Chairman of the Traction Technical Committee**

THERE is no sign of any diminution in the growing use and application of electricity, which are extending throughout the world into many new and surprising fields; we now generally accept electricity as an almost indispensable part of our modern civilization. It is paradoxical that, while those responsible for the railways in Britain have not failed to grasp the advantages of electricity for their ancillary purposes, they have shown only little similar enterprise in their chief railway function, the operation of trains. In suitable conditions, electric traction can be the most efficient and most economical form of motive power that is known to-day.

Britain created the steam locomotive. Through the locomotive she pioneered the world's railways, and became supreme in the field of railway traction. But supremacy can be maintained only with constant new invention, and the steam locomotive, apparently incapable of any further substantial improvement, must give way to other more efficient and modern forms of motive power.

Practically the whole of the railway traffic in Sweden and Switzerland is worked by electric traction. The steam locomotive will soon almost entirely disappear from the Netherlands Railways. A large proportion of the Italian Railways is electrified. The French Railways are an outstanding example of electrification progress. In many large cities throughout the world the movement of suburban rail traffic would be impossible without electrification.

These are a few examples of appreciation, mostly by other countries, of the economic value of electrification. Electrification has proved to be a sound investment paying good dividends, which are made possible by savings in annual working expenses, notably in fuel and maintenance. With suburban electrification, revenue has increased owing to increased traffic.

The Southern Railway Company in the period 1925–1939 embarked on a large, continuous programme of electrification, which was stopped by the war. But since then only two electrification schemes have been inaugurated, namely Liverpool Street–Shenfield, and Manchester–Sheffield–Wath; these schemes were authorized so far back as 1936, since when an extension to the Shenfield line has alone been approved. It is amazing that Britain, an electrically minded nation, is so far behind contemporary thought on electric traction.

The national coal position is already serious and in the years ahead it may be desperate. The demands of industry are growing; it is estimated that the annual consumption of coal increased by about seven million tons in 1954. Motors, chemicals, mechanical engineering and gas are among the industries whose levels of output are requiring more coal than ever before, and the demands of the B.E.A. are now becoming very large. Dual firing of oil and coal is being adopted in some power stations, and oil firing is already in use in another. In an endeavour to get more coal the vast capital expenditure on collieries continues to grow: soon it is expected to be at the rate of £100 million per annum. Britain is at present importing coal from America and Germany.

The development of nuclear energy is now proceeding rapidly. It is hoped that it will make up for the growing deficiency of energy available from our rapidly dwindling national coal resources, in sufficient quantity to replace an annual coal consumption of 20 million tons after about 1965. The electrical industry is making a splendid contribution to the conservation of fuel by increasing progressively the thermal efficiency of generating stations towards a target of 40%.

In face of this it is incredible that in Britain the reciprocating steam locomotive continues irresponsibly to consume annually about 14 million tons of our best coal, operating at a thermal efficiency which, on the most optimistic view, cannot average more than 6%. Even worse, an additional and enormous amount of coal is lost non-productively in the preparation of locomotives, in cleaning fires, in standing by, in washing out boilers and in other functional purposes. From the standpoint of fuel efficiency this is ridiculous.

It is impossible to dissociate the steam locomotive from gloomy smoke-filled running sheds. With electric traction, running sheds and inspection depots can be clean, bright and cheerful. The drudgery and dirt associated with coal dust, ashes and steam disappears, leading to better morale of the workmen, higher standards of maintenance, and less risk of locomotive service failures from the unavoidable dirt in steam-locomotive running sheds. The duties of an electric locomotive driver are physically light. He can be provided with a clean and comfortable cab, draughtproof and heated to suitable temperatures in winter, and, because of the ease of control of the electric locomotive, he can concentrate entirely on the road without distraction.

It takes little imagination to envisage the effect of smoke elimination on our busy stations and other railway

property. It has been said that nearly 20% of the smoke and atmospheric pollution of the country is due to steam locomotives. An approximate but authoritative assessment recently stated that the railways of Great Britain were responsible for losses due to atmospheric pollution of the order of £20 million per annum, equivalent to some 27s. for each ton of coal burnt.

There are no technical obstacles to be overcome with electrification. It may well be that invention in the future may produce equipment which is better in detail, or that some quite revolutionary and fundamentally superior invention may appear: e.g. the atomic locomotive. (A preliminary American design for this appears to be impracticable for a number of reasons.) There is also the gas turbine, but speculation on future perfection can quite easily cause the loss of immediate and permanent advantages. Any controversy on the system of electrification to be adopted should no longer be tolerated, for otherwise a start with large-scale work will never be made. This question has been thoroughly investigated by no fewer than three committees, with almost similar conclusions, namely that Britain should use the 1 500-volt d.c. overhead system, with provision for alternative systems, if these were more economical, for secondary lines.

There is no doubt about the ability of British industry to undertake large-scale electrification in Britain. Experience has been obtained all over the world under widely diverse climatic, operating and technical conditions. Manufacturing capacity is already ample and can, if necessary, be expanded to meet any reasonable acceleration of electrification which may be approved. A base load on our industry would materially assist our export business.

From time to time some doubt is expressed about the security of our railways under electric operation. It is said they would be vulnerable in war. If an enemy attack were sufficiently widespread to inflict serious damage on power stations, it is likely that British industry would also be very seriously affected, probably leading to a substantial reduction in rail traffic, quite apart from any curtailment of the services which might be caused by reduced power supply. In envisaging such a calamity we may well assume that damage to bridges and other railway equipment would be on a scale such that no trains at all, steam or electric, could run on many routes. Actual war experience, both in this country and abroad, has proved that damage to line equipment can be made good and power supply arrangements can be restored well in advance of repairs to the track itself. The rolling stock on electrified systems is less vulnerable to damage than steam locomotives. It is possible to disperse electric locomotives or electric multiple-unit trains throughout a railway system, and, in emergency, inspection and other attention can be arranged under these conditions. With steam locomotives, however, concentration at one point for coaling, watering and other attention cannot be avoided, and the risk of destruction of large numbers of locomotives is great. It is significant that in the face of the great damage suffered in the 1939–45 War, the French and Dutch railways are proceeding with large-scale electrification.

The foregoing remarks should settle the doubts about and objections to electrification that are raised often by uninformed and irresponsible people, and sometimes by interests vested in the continuing use of steam traction.

In Britain the steam locomotive is an anachronism, and the time has arrived when we can no longer afford to postpone electrification. In looking forward, it is wise to look back to see what can be learned from experience. In retrospect it is very clear that had large-scale electrification followed the Weir Report of 1931 our railways would be much more flourishing in 1955. To-day, the capital outlay will be much greater, even with electrification on a reduced scale, but immense expenditure is now commonplace in industry, both national and private.

Our railways cannot pay for electrification from revenue earnings, but there should be no difficulty in raising capital for sound financial investment in electrification. Electrification would prove highly attractive financially. It could restore our rail transport to a premier place, enabling it more easily to compete with other forms of transport that have improved and encroached on the railways for many years past.

Improved speed, comfort and frequency of passenger trains are synonymous with electrification. Freight services can also be improved. Grime and smoke can be reduced. Electric traction is quite independent of the nature of the fuel or energy available, be it coal or oil, hydraulic or nuclear. Undoubtedly all these advantages are of much value to Britain, and by electrification the face of her railways would be rejuvenated, with a lift in morale and a reduction in working expenses.

We are proud of our railways, but time goes on and brings increasing progress in other countries, while Britain remains paralysed. Pride cannot walk with paralysis. Why is electrification so slow? Not because of material reasons, but patently owing to a lack hitherto of imagination and forceful enterprise, which should no longer be tolerated by the British people.

Recently there has appeared evidence that this antique railway era may be closing at last. There is promise of great change in outlook towards reconstruction of our railways with a plan including large-scale electrification. The nation will admire courage and determination in this respect, and the reward will surely be great.

[Not every member of the Traction Technical Committee endorses this article in its entirety—*Editor*.]

THE NEW PRESIDENT

THE INAUGURATION OF MR. J. ECCLES

At the Opening Meeting of the 1954–55 Session the new President, Mr. J. Eccles, C.B.E., B.Sc., was introduced to his high office in the traditional manner by the retiring President, Mr. H. Bishop, C.B.E., B.Sc.(Eng.). An abstract of Mr. Eccles's Inaugural Address appears on page 20.

THERE were friendly greetings and an atmosphere of reunion among members of all ages when they met in the Library before the Opening Meeting of the new session, on the 7th October, 1954. Soon the Institution's Lecture Theatre became crowded with over 500 members and guests, and late-comers had some difficulty in finding seats. As members entered the Theatre they saw that the walls were lighter. The dark surface of the mahogany has been treated and returned to its natural colour, and the grain of the wood is now much more apparent. Most members will agree that the Theatre is now a more inviting place in which to listen and to debate. Was it imagination, or did the fathers of electrical engineering smile from their portraits on October 7th with increased delight in their eyes? Certainly there was no need for their indulgence in an evening which included the President's masterly and fascinating Address and some speeches of high wit and charm. Members appeared glad to be at an Institution meeting once again after all the varied activities of summer evenings, and there was a hush of anticipation as Mr. Bishop took the chair at 5.30 p.m. With him on the dais were the President, two Past-Presidents, three Vice-Presidents, and the Secretary. Many Council members, their ladies, and other distinguished guests were among the audience.

After an announcement that Mr. Bryan Donkin had been appointed to the Council, under Bye-law No. 54, to fill a casual vacancy caused by Dr. Willis Jackson's election as a Vice-President, Mr. Bishop welcomed 21 new Corporate Members with the customary ceremony. Addressing these members, Mr. Bishop said: "It gives me great pleasure to welcome you as Corporate Members of The Institution, and I enjoin you to do all in your power to maintain our high traditions and to promote the aims denoted in our Royal Charter." The Secretary then announced the name of each new member in turn, who, as his name was called, advanced and was personally welcomed by Mr. Bishop. Next followed the annual award of premiums to the authors of papers submitted during the previous session. Apart from those who had chosen to have their premiums awarded in the Local Centres, most of the recipients were able to be present. Having received his premium personally from Mr. Bishop, each was acclaimed by his fellow-members at the meeting. There was prolonged clapping for the French authors of two papers on electric traction, M. F. Nouvion and M. M. Garreau, who received the Paris Exhibition (1881) Premium.

The meeting had now reached the kernel of the evening's business, the President's Inaugural Address. Mr. Bishop expressed his pleasure in welcoming Mr. Eccles and without further ado called on him to deliver his Address (see page 20).

After the President's Address had been received with much enthusiasm, Mr. Bishop asked **Mr. J. R. Beard, C.B.E., M.Sc.,** to propose a vote of thanks to Mr. Eccles. Mr. Beard said:

"The Institution is most fortunate in the very high standard of the Presidential Addresses delivered to it, and we have come to expect of each new President a broad, authoritative survey of some branch of the electrical engineering profession with which he is more particularly concerned. The Address which Mr. Eccles has given not only challenges any of those which have been delivered in the past, but stands out as a supreme example of imaginative thinking and clarity of expression. We should be thankful that Mr. Eccles felt that the subjects with which he is concerned in his day-to-day work had been so thoroughly explored in recent times that he was impelled to depart from tradition and attempt something of a more imaginative nature. By this extraordinarily broad survey of the distant past and the more probable future of power engineering he has kept us all entranced. I know that when the Address is published many more will be equally entranced by it.

"I personally feel, as I am sure that you do, lost in admiration for the wide reading of our President, for his ability to let his imagination play over the past millenniums and the future centuries, for the capacity he has for picking out the essentials, and for the skill with which, in so brief a time, he has left us with the feeling that we have a new conception of the fundamentals of power engineering and of the place which it will occupy in the future of mankind. In doing so he has kept his imagination subordinated to practical considerations. I think that his calm and objective approach to such topical matters as, for example, atomic energy is most intriguing, and is a useful corrective to the bursts of popular enthusiasm which from time to time make it a little difficult for the power engineer to get approval for his projects and the finance to carry them out.

"With that genius which makes difficult things simple, the President has made his subject of absorbing interest to all grades and sections of our membership, and, I strongly suspect, to a wider public than is normally inclined to take much notice of presidential addresses to

learned societies. In some strange way I feel, too, that his Address has left us with a sense of emotion similar to that which one feels after watching a fine play, or listening to some outstanding piece of music. When this happens one is loath to break the spell by undue applause, and therefore I am sure that you would wish me to thank Mr. Eccles in the very simplest way for his Inaugural Address, and, in the historic words of The Institution, to propose: 'That the best thanks of The Institution be accorded to Mr. J. Eccles for his interesting and instructive Presidential Address, and that with his permission the Address be printed in the *Proceedings* of The Institution.' "

The vote of thanks was seconded by **Dr. Willis Jackson, D.Sc., D.Phil., F.R.S.,** who said:

"It gives me great pleasure to second the vote of thanks proposed by Mr. Beard to our new President for what I think has been a very inspiring Address. As you all know, our President has devoted his professional life to the organization and administration of electric power supply and has made a great success of it. After hearing him this evening, I consider that he could have made a first-class teacher; indeed, I have little doubt that he has been, and still is, one in his own particular environment.

"It is perhaps natural for me to pick out his reference to the importance of the need for more of our best schoolboys to enter upon the study of engineering. Our Education and Training Committee and the Council itself have devoted very considerable attention during the past few years to conceiving means by which schoolboys, their parents, and their masters may become better acquainted with the nature, the attractions and the prospects of engineering as a career; and better acquainted with the fact (as we believe it to be) that the pursuit of an education, a training and a career in engineering is as searching, as character-building, and as productive of real culture as the pursuit of one in the arts and humanities. I doubt, however, whether in their several reports and memoranda the Education and Training Committee have produced anything so valuable for achieving these ends as our President's Address to-night.

"He has caused me to look at the history of man's development from a new angle, and he seems to me to have lifted our need for an enhanced recruitment to engineering from the plane of competitive expediency, where some would place it, to the more real one of evolutionary necessity. He has done more than this; he has made it very clear that we ought to do more to ensure that those who have already chosen to be engineers become better acquainted with the history of science and engineering and the way they have reacted on, and determined the nature of, man's environment and his mode of life, both nationally and internationally.

"Mr. Eccles referred to the processes of the fission and fusion of nuclei. Perhaps The Institution could be thought of as a nucleus, with four possible fission elements or particles, our four Specialized Sections, which are fused together through our various inter-Section Committees, through the Council and overall by the President himself. I suggest to you that addresses such as you have heard this evening and men with the ability and breadth of outlook of Mr. Eccles, are an adequate guarantee of the non-fissionable character of The Institution. I have much pleasure in seconding the vote of thanks."

The vote of thanks was put formally to the meeting and carried with prolonged applause.

Mr. Bishop then declared that his final act before "sliding into oblivion" was to vacate the chair and invite Mr. Eccles to occupy it. He said, "You know Mr. Eccles as well as I do. He has a tremendous past and a tremendous future. He has done a tremendous amount for the B.E.A., and in his present highly responsible position with them will, I have no doubt, find great difficulty in doing not only his normal work but also his work as President of The Institution. I am sure that we all wish him well in his year of office."

Mr. Eccles took the chair in place of Mr. Bishop and called on **Col. B. H. Leeson, C.B.E., T.D.,** to propose a vote of thanks to the retiring President. Col. Leeson said:

"I have the honour of being Mr. Harold Bishop's nearest relative in the line of Past-Presidents. Because of that fellowship, I have the privilege of proposing the vote of thanks to the retiring President for the magnificent work that he has done during his term of office.

"During the ceremony of welcome earlier in the meeting, Mr. Bishop, addressing the new Corporate Members of The Institution, said '. . . and I enjoin you to do all in your power to maintain our high traditions and to promote the aims denoted in our Royal Charter.' Mr. Bishop not only has spoken these words, he has lived up to their precepts; and, in fact, he has done all in his power for The Institution. Indeed, it is surprising how much power has emanated from a light-current engineer working at extra-high pressure.

"The session now ended has been one of notable progress, and I know that I reflect the views of our members when I pay tribute to Mr. Bishop for carrying out his many duties with great competence, with dignity and that personal charm which has won him and The Institution many friends. For all that you have done, and done so well, I ask you, Mr. Bishop, to accept the appreciation and gratitude of all your colleagues.

"As an introduction to my next point—the President has encouraged one to delve into the past—I will quote a parody on Omar Khayyám:

Think, in this Building with its grand Array
Whose Doorways are alternate Night and Day,
How each President, named upon its Walls,
Abode his Year or two, and went his Way.

"Now, 'went his way' does not mean that the retiring President will not continue to serve The Institu-

tion, and one of the first things I want to do is to welcome Mr. Bishop as the new Immediate Past-President. If I were on television I might say 'Down you go,' but now that Mr. Bishop has joined the Past-Presidents it is 'Up you go'—onto the shelf; and I assure you, Mr. Bishop, that you will not find it dusty! We look forward to benefiting in the future, as we have in the past, by your wisdom and valuable experience in the Council, in Committees, and in other directions.

"From where come these qualities? Our Secretary at times uses the term 'penetration factor.' This factor, like others, has the merit of being as enigmatical as it is convincing, but when I say that Mr. Bishop's penetration factor into every facet of The Institution's widespread activities is very high—or is it very deep?—you will all know exactly what I mean.

"Another important side of the Presidency is that of speaking at social and other occasions, and we are proud of Mr. Bishop's accomplishments on such occasions. You realize when he gets up to speak he does know what he intends to say; when he is speaking he does appreciate what he is saying; and when he has sat down he does remember what he has said!

"During the Commonwealth Engineering Conference held in London last year, Mr. Bishop presided over many meetings. At these there arose many problems of which he had little if any warning, and the manner in which he helped to resolve them by his knowledge, tact and humour, and by his skilful Chairmanship, is a typical illustration of what he has done in so many ways for The Institution.

"No less successful was the social side of the Conference. I voice this especially because it shows the all-important part that has been played during the Presidential year, and played so happily and so loyally by Mrs. Bishop. She has helped and supported her husband in countless ways, both large and small. I do not know whether they appear in Mrs. Bishop's diary, but in my wife's diary you will find mystic letters such as D.J. (dinner jacket), E.D. (evening dress), and even E.D.D. (evening dress with decorations), or, as she became more experienced, ED^2. For your invaluable help, Mrs. Bishop, given in so many ways and with such grace and charm, we ask you to accept our deep and heartfelt thanks.

"For both Mr. and Mrs. Bishop, this Inaugural Meeting of the coming session marks the passing-on of the many and arduous duties of the Presidency and marks also the opportunities for leisure that lie ahead. One can visualize them spending a well-earned evening at home, and in the flickering firelight being able soon to enjoy the change of an exciting programme on television—from the Independent Television Authority.

"All this may be summed up by another parody on Omar Khayyám:

How sweet is the Presidency—think some:
Others—How blest the Passing-On to come!
Ah, take the just Reward of well-earned Rest;
Enjoy the Music of a Task well done.

"And so there remains the task of instrumenting the music of a task well done. The instrument that I have the honour to play in a duet with Sir George Nelson is the Resolution: 'That the best thanks of The Institution be accorded to Mr. Harold Bishop for the very able manner in which he filled the office of President during the past year.'

"The accompaniment will be played by all of you here to-night on the instruments—the percussion instruments—of your own hands. In this way, let us orchestrate the grateful feelings of our hearts so that there may resound in this Theatre and re-echo in the memories of Mr. and Mrs. Bishop the music of a task well done."

Mr. Bishop receives the Certificate of Presidency from Mr. Eccles

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In seconding the vote of thanks, **Sir George H. Nelson** declared, "It is the traditional privilege of the senior Vice-President to second this vote of thanks. I do it not only because of this tradition but because it gives me the very greatest pleasure to do so. I have known Mr. Bishop for a great number of years. I have been associated with him professionally and with the work for which he is so well known and honoured, and in that work he has brought, through his Presidency, further distinction to this great Institution and its activities.

"He succeeded to the Presidency soon after the Coronation of our gracious and beautiful Queen. As many of you know, I have had the opportunity and the privilege to travel in many countries of the world, and I say to you that we as members of The Institution and as British men and women owe him a tremendous debt for the way in which he and his colleagues brought the beauty and the sacredness of this traditional ceremony to the world and showed what we in England stand for. By his leadership of the technical side of this work, and by the inspiration that he put into it, he has further enhanced Britain's reputation in the world, and the acknowledgment of this by people everywhere is something which cannot fail to touch your heart when you visit foreign countries.

"I also congratulate him on the wonderful way in which he has filled the office of President. I should like to add to what Colonel Leeson said about his devoted wife. I know her well too and can testify to the way in which, by her devotion to him and his work for The Institution, she has helped Mr. Bishop in all his efforts.

"With these few words—few, but deeply sincere—I have the greatest pleasure in seconding the vote of thanks."

Mr. Eccles then declared, "Before putting that vote of thanks for your final approval, it is my very great privilege and pleasure to present to Mr. Bishop the Certificate of his Presidency. Mr. Bishop, you have heard all that has been said, and even that is not sufficient to indicate your worth and our gratitude for all that you have done for The Institution. This will be a constant reminder of the place which you occupy in the hearts of our members, and not only you, but also Mrs. Bishop."

The vote of thanks was carried with prolonged applause, and **Mr. H. Bishop, C.B.E., B.Sc.(Eng.)**, rose to reply.

"I very much appreciate," he said, "everything that has been said by Colonel Leeson and Sir George Nelson. I have detected a certain measure of exaggeration in some of their statements, and possibly even some disregard for the truth on the part of these two eminent engineers. If I were a shareholder in the organizations for which they are responsible I should find that rather disturbing. Be that as it may, their remarks have been very generous and kind, and I thank them for what they have said.

"Being President of our Institution is a most exciting and rewarding job. As I feared when I took office—and I imagine it is the feeling of most Presidents—I was simply unable to do all that I wanted to do. There is so much to do and so little time to do it. I had hoped, to take one example only, that the negotiations on higher technological training with the Ministry of Education might by now have been completed. Though we have made some progress, we have not settled them entirely, and I hope sincerely that their completion will not be long delayed.

"Colonel Leeson mentioned the Commonwealth Engineering Conference, which I think has been the outstanding event of the past year. It was a great pleasure for me and for all those in The Institution who were with me, to meet the Presidents and Secretaries of Engineering Institutions from all over the Commonwealth. We were all impressed by the high standing which quite obviously The Institution enjoys in the minds of our visitors from oversea. There is a great value, I think, in these Commonwealth Conferences.

"I have been proud to be the temporary head of The Institution. Visiting the Centres has made me realize, more than ever before, the vast field of interests which our members cover, and the determination of our members all over the country—and abroad too—to maintain and extend the influence of the electrical engineer. I am not sure that we are doing enough in that way. I think that, as Dr. Willis Jackson said, we have a long way to go to make sure that the engineer has his rightful place in the community, and there must be no relaxing on our part in seeing that it is achieved. Sometimes I feel that people are afraid of science and do not quite know what it is, and because of that they think of it as something apart. There is a great job here for every engineer, to do his best to bring together the two sides of our civilization, the humanities and the sciences, and to avoid that division between them which is so often apparent.

"Another thing which has been outstanding in the past year is the continuation of the close co-operation between the three major engineering Institutions. It is a marked feature of our work in these days.

"Needless to say, I have had the fullest possible support of the Vice-Presidents, who work very hard, and of the Council and of all the Committees, who do innumerable things for the President during his term of office. That support is freely and unstintedly given.

"It is customary too on these occasions for the retiring President to thank the Secretary and staff of The Institution for their work for him. I say that it is customary, but I have appreciated that help very greatly indeed, and I make this point not as one which is customary but as something that I feel most deeply; the work of Mr. Brasher and his staff is outstanding, and the skill and willingness with which they support the President and run The Institution's business have made a deep impression on me.

"I should also like to mention the fact that during the past year there occurred the sad death of Mr. Graham Clark, the Secretary of the Civils. That, as he had been the senior of the three Secretaries, has put a considerable additional load on Mr. Brasher.

"It will fall to most of us in due course to have our name and certain other particulars carved on a piece of stone or marble, but we shall, unfortunately, be incapable of taking any interest in that event. The Presidents of The Institution, however, are in a class by themselves; they actually see, and can take an interest in seeing, their names carved on the marble wall. To one Past-President at least, that gives great pride and pleasure. I thank you very much for your kind vote of thanks."

In a short closing speech, the President said that he would like to thank Mr. Beard and Dr. Willis Jackson for their flattering remarks about his Address, and the audience for the attention which they gave to his "all too long oration." He also thanked by name those who had aided him in the preparation of the Address.

Thus ended two hours of admirable instruction, inspiration and entertainment, which will be remembered as a stimulating opening to the activities of the session. For the first time copies of the President's Address were available for members to take on leaving the Lecture Theatre, and thus they have not, as in former years, had to await the January issue of the *Proceedings* for the full text of the Address.

Journal I.E.E., January 1955

The performance of STAR-STAR TRANSFORMERS

Professor R. O. KAPP, B.Sc., *Member*
A. R. PEARSON, B.Sc., *Associate Member*

To obtain a satisfactory performance with a star-star transformer it is sometimes, but not always, necessary to provide the transformer with a delta-connected tertiary winding. Much misapprehension exists among electrical engineers about the reasons for such a winding, and most users of these transformers in Britain demand a delta winding in all instances, although, in fact, its additional cost is often not justified and its provision is technically undesirable. The subject is rarely mentioned in textbooks and then, as a rule, only briefly. The authors of this article explain in plain words when a star-star transformer should be fitted with the extra winding. This will be familiar to transformer specialists, but it is believed that the article will be useful to many other electrical engineers who use star-star transformers and enable them to decide whether a tertiary winding is necessary in a particular transformer. The authors show that in most instances a decision can be reached easily and without an exact numerical assessment.

STAR-STAR transformers are often provided with a delta-connected tertiary winding for one or more of the following reasons:

(i) To provide auxiliary terminals at a voltage different from the primary and secondary voltages of the transformer.

(ii) To allow sufficient earth-fault current to flow for the operation of protective gear.

(iii) To prevent the transformer from introducing triple-frequency voltages into the network.

(iv) To keep the voltage rise on any phase within narrow limits in the event of any unbalance of the load between phases.

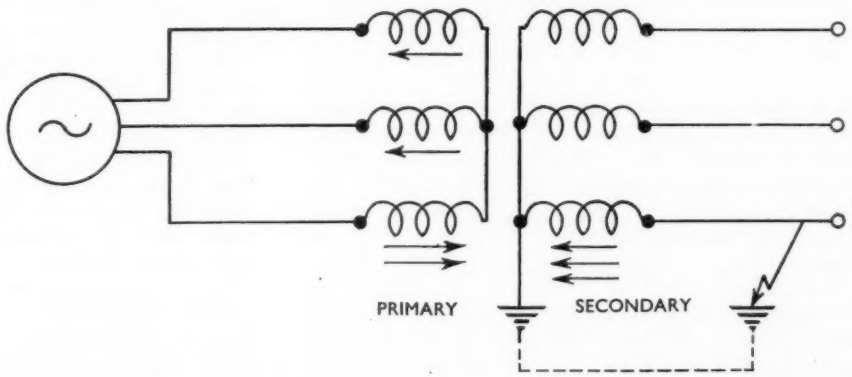
The first of these reasons is obvious and does not need further discussion. When it applies, the winding should be called auxiliary rather than tertiary.

In practice, whatever the purpose of the tertiary winding its conductor cross-section is usually determined by the necessity for it to withstand fault conditions. This requirement often calls for a much more expensive winding than would suffice for the purpose for which the winding is provided.

Flux Distribution during an Earth Fault

Suppose that a star-star transformer has its neutral points earthed both on the primary and secondary sides and that, in addition, the power source connected to the primary side has an earthed neutral; then in the event of an earth fault on one phase of the secondary the power current would be confined to one limb of the transformer and of the power source and would be able to return through the earth connections without materially affecting the other phases. In these circumstances the affected limb of the transformer would behave very much as a single-phase transformer and the reactance to the earth-fault current would be of the same order as that to a normal power current.

In the more usual circumstances where the neutral point of the transformer is earthed on the secondary side only and not on the primary, the primary power current feeding the fault cannot return to the power source via earth and has to return via the two other phases, as shown in Fig. 1. As a result, an earth fault on the secondary connection from one limb of the transformer produces currents flowing in the windings on the two other limbs, and the behaviour of the transformer as regards reactance to the earth fault can be expected to

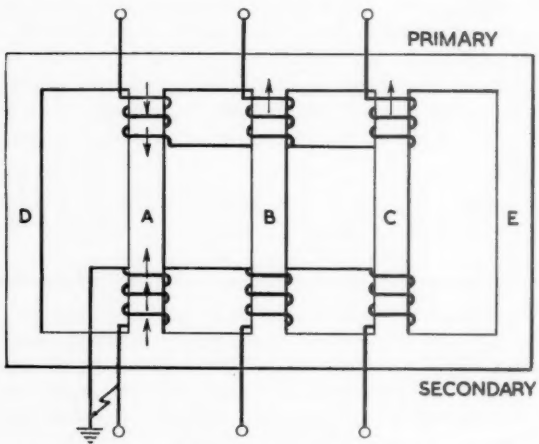


1 *Flow of earth-fault current in star-star transformer*

differ materially from its behaviour with a normal 3-phase power current.

Let us consider, therefore, a star-star transformer having the neutral point earthed on the secondary side, but not on the primary side, and with an earth-fault current flowing from one secondary connection, with corresponding currents in the primary as shown in Fig. 1. We assume for the sake of simplicity that the transformer is not supplying any load current. The 3-phase magnetizing current taken by the transformer is small compared with any fault current required to operate protective gear, and the approach to a consideration of flux distribution will be easier if, to begin with, this small magnetizing current is ignored and the single-phase earth-fault current alone is considered.

Fig. 2 shows a five-limbed core-type transformer together with its primary and secondary windings. The arrows represent magnetomotive force (often called ampere-turns, though an ampere-turn is rightly a unit of measurement). Limb A forms part of a magnetic

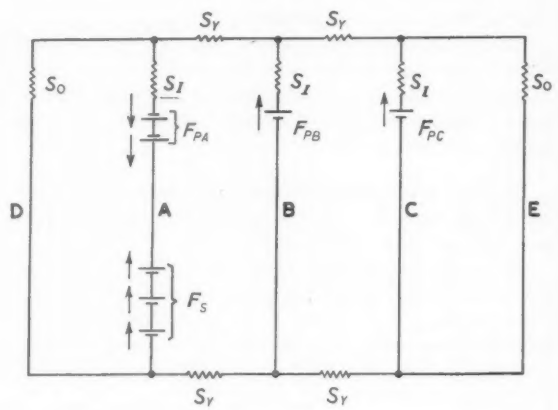


2 *Five-limbed core-type transformer subjected to earth fault*

circuit that is completed through the other limbs. This circuit without the windings is shown in Fig. 3, and to make the analogy between a magnetic and an electric circuit more apparent, m.m.f. is represented by the standard symbol for a battery. The reluctances of the outer limbs, inner limbs, and portions of the yoke are respectively S_O, S_I, and S_Y.

The secondary coil on A being short-circuited, the voltage induced in it will necessarily be small. Any flux caused by the m.m.f. in this secondary coil must therefore nearly balance the inducing flux, which is caused by the m.m.f. in the primary winding. As will be seen from Figs. 2 and 3 the magnetic circuit is disposed so that the m.m.f.'s F_{PB} and F_{PC} are in parallel with each other and both are in series with F_{PA}. Hence the circuit contains in all a primary m.m.f. that can be represented by three arrows in series and pointing round the circuit in an anti-clockwise direction. If no allowance is made for leakage flux, the secondary m.m.f. is therefore correctly represented by three arrows in series and pointing round the same circuit in a clockwise direction, as shown in the Figures.

It will be seen that an unbalanced single-phase flux,



3 *Magnetic circuit of Fig. 2*

known as a zero-phase-sequence flux, remains. It passes in the same direction through the three inner limbs shown in Fig. 2 and returns through the two outer ones. The magnetic potential difference between the upper and lower yoke required to force this flux through the limbs D and E is produced by the m.m.f.'s F_{PB} and F_{PC} on limbs B and C and by the difference between F_S and F_{PA} on limb A. The distribution of currents shown in Fig. 1 is the only possible distribution that can produce equal resultant m.m.f.'s on all three limbs.

In other words, the five-limbed transformer represented by Fig. 2 acts as a single-phase choke coil when an earth fault occurs on a secondary phase. Its effectiveness in this capacity depends on the value of the reluctance S_O of each outer limb. The smaller this reluctance the smaller the fault current required to produce the necessary single-phase flux and the greater the choking effect. The reluctance is small in both a five-limbed core-type and a shell-type transformer, as also in each of three single-phase transformers connected to form a 3-phase star-star connected bank. For in all of these the single-phase flux has a return path in iron as shown in Fig. 2. These types pass very little earth-fault current. But if an air-gap were introduced into the outer limbs shown in Fig. 2 the value of S_O would increase greatly; if these limbs were omitted it would be greater still, since the return path would then be largely in air or oil. This is why a three-limbed star-star connected transformer behaves to earth-fault currents more like an air-cored than an iron-cored single-phase choke coil. In other

words, it passes a substantial earth-fault current since its zero-phase-sequence reactance is not great.

Quantitative Evaluation

The above qualitative considerations suffice to show that the quantitative difference between the zero-phase-sequence reactance of a three-limbed core-type and the other types of transformer is great. Hence precise quantitative assessment is only very rarely necessary for a general appreciation of the performance of the transformer. However, a brief reference to the work done in this field will not be out of place.

Various authors have provided formulae that enable the transformer designer to calculate the zero-phase-sequence reactance with fair accuracy. The subject is discussed by Coleman in an E.R.A. Report,[1] where it is shown that the zero-phase-sequence reactance X_0 depends on the number of turns on the windings, the length of the yoke, the ratio of diameter to length of yoke, and the ratio of distance between the yoke axes to length of yoke. In conventional designs these ratios do not vary between wide limits. Considering mean values and allowing for the effect of the tank in providing a portion of the path for the above-mentioned single-phase flux in a 3-limbed core-type transformer, the rather complicated formulae given in the E.R.A. Report can be simplified to give

$$X_0 = 1{\cdot}6aN^2 \times 10^{-5} \text{ ohm per phase}$$

where a is half the total length of yoke in inches and N is the number of turns per phase of the winding to which the reactance is referred.

The percentage impedance is then

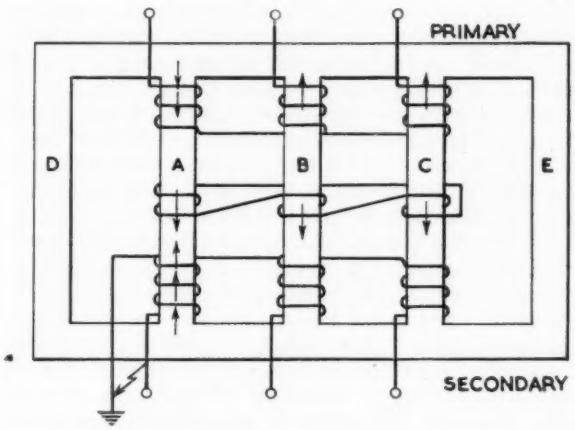
$$x_0 = 100V'/V = 0{\cdot}16aN^2P/V$$

where V' is the voltage drop (in volts) on full load occasioned by the reactance X_0, V the rated voltage in volts, and P the rating of the transformer in kilovolt-amperes. Tests on typical transformers have shown results for x_0 that are in close agreement with this formula and that lie within the practical limits of 30% and 90%, which have been given by E. T. Norris to the authors as the normal range of values for x_0.

This means that with three-limbed core-type transformers of conventional designs one can rely on earth-fault currents greater, and often much greater, than the rated full-load current of the transformer; earth-leakage relays can detect them with certainty. Hence a tertiary winding could not be justified if its sole purpose would be to increase the earth-fault current. And yet occasions are not unknown where such a tertiary winding has been provided for this sole purpose, and a neutral earth resistance has been provided with the opposite purpose of restricting the earth-fault current.

Effect of the Tertiary Winding

Fig. 4 shows the transformer represented by Fig. 2 when a delta-connected tertiary winding is added. The voltages induced in each phase of this winding by an unbalanced single-phase flux have the same direction round the circuit. Hence a current flows in this winding during an earth fault on the secondary side. This



4 *Star-star transformer with delta-connected tertiary winding*

current, multiplied by the number of turns in the tertiary winding, gives an m.m.f. of sign opposite to that set up by the short-circuit; the magnetic potential difference between upper and lower yokes practically disappears, and the back e.m.f. to single-phase current is limited by the leakage reactance and resistance of the winding. But no current flows in the tertiary winding during normal working, for the 3-phase field induced in the transformer is such that the sum of the fluxes in the three limbs is zero.

Earth-fault considerations thus always make a tertiary delta winding necessary for a bank of three single-phase transformers, for a five-limbed core-type transformer, or for a shell-type transformer, which is star-star connected with the primary neutral point unearthed. But a tertiary winding should not be fitted to a three-limbed core-type transformer on account of earth-fault protection. The rare instances in which such a winding may be needed are governed by reasons (iii) and (iv) and we now pass on to consider these.

Triple-Frequency Voltages

When a sinusoidal voltage is applied to the primary winding of a single-phase transformer the magnetizing current is not sinusoidal but contains higher harmonics, of which the third is particularly pronounced. The value of the third harmonic depends on the maximum flux density reached in the core and varies in practice between 30% and 70% of the fundamental.

In a balanced 3-phase system the component vectors

of the fundamental current are displaced from each other by an angle of 120°. Those of the third harmonic are displaced from each other by three times this angle, or 360°, which means that they coincide; they constitute a triple-frequency single-phase current. If the neutral point of the primary winding of the star-star transformer is earthed, this current returns through earth to the power source and the flux in each limb of the transformer is sinusoidal. If, however, the primary neutral is not earthed, triple-frequency currents cannot flow and a triple-frequency flux appears in each limb of the transformer. Having the same direction in each inner limb, it could be represented in Fig. 2 by three arrows pointing upwards in the three limbs A, B and C. In a five-limbed core-type transformer there is a low-reluctance magnetic path for the triple-frequency flux and a marked triple-frequency component appears in the line-to-neutral voltage. In a three-limbed core-type transformer, however, there is no closed iron path for the triple-frequency flux. The magnetic potential difference required to force the flux through the air path can be produced only by an increase in the first, fifth, seventh, etc., harmonic components of the magnetizing current. The amplitude of the triple-frequency voltage appearing between line and neutral will be less than $X_0 I_3$, where X_0 is the zero-phase-sequence reactance of the transformer and I_3 is the third-harmonic component of the magnetizing current that would flow if the primary neutral were earthed.

If a tertiary delta winding is fitted, a triple-frequency magnetizing current equivalent to I_3 circulates in this winding and the line-to-neutral voltages are substantially sinusoidal. Even when a tertiary delta winding is not fitted, the value of $X_0 I_3$ does not exceed 2% to 3% of the fundamental in a three-limbed core-type transformer. Only when this small ripple cannot be tolerated does a tertiary winding become necessary.

Voltage Rise with Unbalanced Load

The unidirectional flux that occurs in each limb during an earth fault induces voltages having the same phase in the secondary windings B and C, as will be seen from Fig. 2. These induced single-phase voltages are superimposed on the 3-phase voltage. As the neutral point is anchored to earth they cause the voltages of phases B and C to rise relative to earth. In any transformer with a complete iron circuit for the single-phase flux the rise is practically from phase to line voltage, or 73%. In a three-limbed core-type transformer it may approach 65%.

Any unbalanced load on a 4-wire distribution system induces similar single-phase voltages, for such an unbalanced load is obviously equivalent to an earth fault of low magnitude. It can be shown that if I_n is the neutral current expressed as a percentage of the rated full-load current, and Z_0 is the percentage zero-phase-sequence impedance of the transformer, the percentage displacement of the neutral point is

$$\frac{I_n Z_0}{3 \times 100}$$

This shows that even when Z_0 is 100%, which is a high value for a three-limbed transformer, the neutral displacement with a 10% out-of-balance current is of the order of 3%.

Effect of Voltage Rise on Lamps

The voltage rise of up to 65% that occurs with an earth fault on a three-limbed core-type transformer might strain the insulation on a very-high-voltage system, where there is not much margin. But star-star transformers are more usually found in distribution systems and there the only things likely to suffer may be lamps.

Temporary over-voltages do not have any appreciable effect on the life of discharge lamps, which anyhow have to withstand a starting voltage of a fairly high order. But tungsten-filament lamps are very sensitive to voltage. Their life is said to be inversely proportional to the 13th power of the voltage and the reduction in their life from that at normal voltage to be proportional to the duration of the over-voltage. On this basis a 5% voltage rise applied continuously would reduce the life of a lamp to 530h if its life at the rated voltage were 1 000h. A continuous over-voltage of 65%, mentioned above as about the maximum that can occur on a three-limbed core-type transformer without a tertiary winding, would reduce the life of such a lamp from 1 000h to 1·5h, or 5 400sec. In other words, every second during which an earth fault lasts robs the lamp of about 10 minutes of its normal expectation of life. The aggregate duration of earth faults on distribution systems during a period of 1 000h cannot be many seconds and cannot, therefore, affect the life of lamps appreciably.

The over-voltages from unbalanced loads are, as mentioned above, at the most of the order of a few per cent and do not persist on any one phase continuously. The effect of these on the life of lamps is therefore not likely to be decisive and is likely to be small compared with voltage fluctuations from voltage drops in the system.

We may conclude, therefore, that three-limbed core-type transformers need be provided with a tertiary winding only in quite exceptional circumstances.

References

(1) COLEMAN, B. E.: E.R.A. Report Ref. Q/T121; 1950.
(2) NORRIS, E. T.: *Electrical Review*, 1926, **99**, p. 56.

Correspondence on this and other articles in the Journal is invited.

The History of Electrical Engineering

I. THE RISE OF ELECTRICAL SCIENCE

This is the first of a series of articles by Mr. Mackechnie Jarvis covering in brief the History of Electrical Engineering from the earliest developments onward. The series will be concerned primarily with the application of electrical science, which is rarely treated in detail in books on the history of science and technology. In his first article the author paints a back-cloth of the important steps in the revelation of electrical science from the time of Peregrinus up to the beginning of the 19th century.

C. MACKECHNIE JARVIS, *Member*

THE progress of the kindred sciences of magnetism and electricity—their union through the discovery of electromagnetism and subsequent development into the science of electrical engineering—is indeed a fascinating story. It is to-day common knowledge that several of the ancient civilizations were acquainted with some aspects of magnetism and with the power of attraction exhibited by amber and similar substances when suitably excited. Nor is this surprising. Iron, itself a common element, though not occurring in nature as a metal, has been known and worked for at least several thousand years. Natural magnets in the form of lodestones or nodules of the magnetic oxide of iron are found scattered over the face of the earth, and amber is a conspicuous mineral found not uncommonly in certain localities. Centuries passed without adding materially to the knowledge of the basic facts which were passed on from generation to generation and circulated from country to country.

Fortunately, there have lived in all ages men whose inclinations led them to set on record the state of knowledge as it existed in their day, and a number of these writings have survived. Many are of a purely repetitive nature, but others display such originality of thought or technique as to become veritable milestones in the progress of our science.

1 *Dr. William Gilbert, 1540–1603*

Early Days

In the 13th century, the focus of the learned world was Rome. Its pillars were largely churchmen, and the centres of culture were the monastic institutions and the few external colleges connected with them. And among individual scholars, the English-born monk, Roger Bacon, was unquestionably the most renowned philosopher in Christendom. Bacon, a friend of Pope Clement IV, was a Franciscan friar, and, although he remained under the discipline of his Order, was for some years a tutor at the new University of Oxford.

Bacon speculated on the magnet, by which he understood lodestone, and wrote of it in several of his works. The clash of his philosophy with the mysticism of his Church and his lengthy imprisonment in Paris are matters outside the scope of this article. He occupies an honoured place in the history of science, not merely for his own writings, but as the tutor of the brilliant Master Peter, better known as Petrus Peregrinus.

Master Peter Peregrinus

To Bacon we owe much of our knowledge of this early experimenter, thus referred to in *Opus Tertium*, written in A.D. 1267: "For there are only two perfect mathematicians, Master John of London and Master Peter of Maricourt, the Picard . . . who is worth more than any of them . . . of whom I have written fully in my *Opus Minus*." "There is no one," says Bacon, "who knows so much of the root of Philosophy . . . and who . . . through experiment gained such knowledge of things natural, medical, chemical; indeed of everything in the heavens or earth."

The famous letter or epistle of Master Peter Peregrinus is addressed to one Sygerus, a fellow crusader. In the words of Silvanus P. Thompson's translation from the Latin original, it concludes thus: "Finished in camp at

the siege of Lucera in the year of Our Lord 1269 on the eighth day of August, endeth this Treatise." It describes in a series of "chapters" the identification and properties of the lodestone, the determination of its poles, its effect on objects of iron, and its use in the construction of instruments such as the mariner's compass. The following quotations from S. P. Thompson's translation[1] will give some idea of the scope of this remarkable tract.

So you must know that this stone bears in itself the similitude of the heavens, the method of proving which I will explain clearly . . . and on this wise; that there are two points in the heavens more noteworthy than the rest because the celestial sphere turns about them as upon axes. One of these is named the Arctic or North Pole whilst the remaining one is named the Antarctic or Southern. So in this stone you should thoroughly comprehend there are two points of which one is called the North, the remaining one the South.

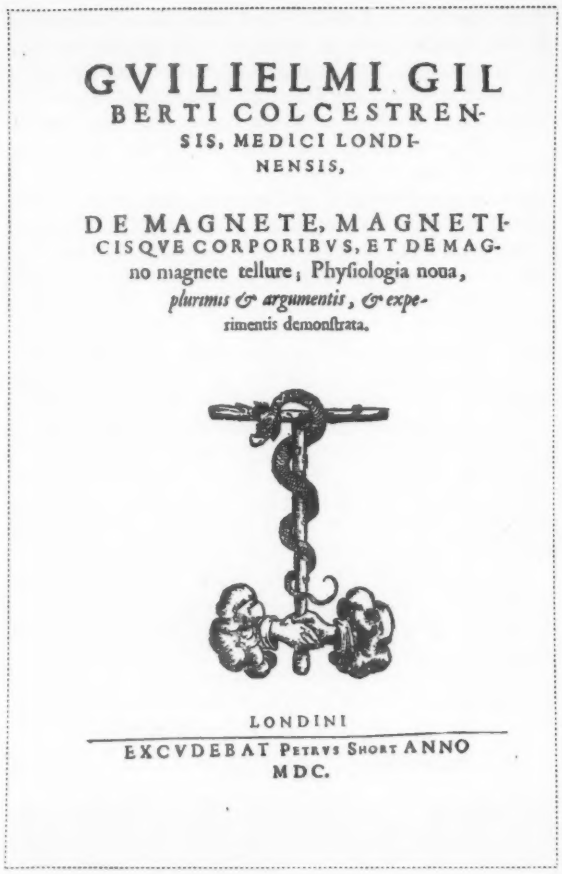
To the general discovery of these two points you may attain by manifold industry. And one way is to have this stone rounded with a tool . . . afterwards let a needle or a bar of iron, slender after the fashion of a needle, be placed over the stone and along the length of the iron let a line be marked out dividing the stone along the middle. Then let the needle or iron be placed in another position over the stone and mark the stone with a line again in the same way according to that position, and if you wish you shall do this in several places or positions and without doubt all the lines of this kind will meet in two points just as all the meridian circles of the world meet in the two opposite poles of the world.

It will be appreciated that at the time when the epistle was written, the earth was held to be a flat and stationary body, around which the heavens revolved.

Having observed the art of finding the Poles of this stone in general, you will ascertain which of them is the North and which the South by means of the following method. Take a round wooden vessel in the shape of a cup or dish and in it place the stone in such a way namely that the two points of the stone are equidistant from the edge of the vessel; then place that vessel with the stone placed within it, in another vessel, a large one, filled with water, so that the stone may be in the first vessel like a sailor in a ship. But let the first vessel be in the second vessel with plenty of room like a ship floating in a river. And, I say, with plenty of room in order that the natural motion of the stone may not be impeded by its contact with the edge of the large vessel. For this stone so placed will turn its small vessel until the North pole stands in the direction of the Northern point of the sky and the South pole in the direction of the Southern point. And if this stone be moved aside a thousand times a thousand times will it return to its place or position by direction of God. And when the Northern and Southern parts are known in the heavens those in the stone will be known also by means of them: because each part of the stone will be in the direction of its own part of the heavens.

. . . as is known to all who have tried it, when an oblong piece of iron has touched a magnet and has been fastened to a light piece of wood or a straw and is put on water, one part will move toward the star called the Nautical Star for the reason that it is near the pole. For the truth is that it does not move toward the said star, but toward the pole, the proof of which we will affirm in its own chapter; but the other part will move toward the other part of the heavens. But as to which part of the iron moves toward which part of the heavens you must know that the part of the iron which shall have touched the South of the stone will turn toward the North of the heavens. And the converse will be the case concerning the part of the iron which the North part of the stone shall have touched, for indeed it will turn round to the South: and it is a wonderful thing for one who does not understand the cause of the motion of the iron: but experience of this has proved that we have spoken the truth.

Here follow an explanation of whence the magnet receives its natural virtue and details of some experiments with a lodestone that is divided midway between its poles, thus creating two magnets. The second part of the Epistle contains instructions for the manufacture of the mariner's compass and lastly "a continually moving wheel elaborated with marvellous ingenuity."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LONDINI
EXCVDEBAT PETRVS SHORT ANNO
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2 *Title page of 'De Magnete'*

Such then was the state of magnetic knowledge before the close of the 13th century and thus it was handed from scholar to scholar and was copied from book to book, frequently with fanciful elaboration, until the middle of the 16th century, when the study of magnetism and electricity received its first systematic attention at the hands of Gilbert.

Dr. Gilbert—"Father of Magnetick Philosophy"

William Gilbert was born in Colchester in the year 1540, and at the age of 18 entered St. John's College, Cambridge, where he was in residence for the ensuing eleven years. He became, successively, a fellow and mathematical examiner, Senior Fellow and, lastly, Senior

Bursar. After a period of several years spent in foreign travel, he settled in London in 1573, and established a medical practice. S. P. Thompson, to whose writings all those interested in Gilbert will ever be indebted, tells us that in 1601 Gilbert was appointed Personal Physician to Queen Elizabeth and attended her in her last illness. Gilbert survived the Queen by a few years only and died at Colchester on the 30th November, 1603, after a plague epidemic. The 18th-century engraving by Clamp which is reproduced in Fig. 1 is taken from a contemporary portrait by Cornelius Jansen dated 1591. The original was formerly at Oxford but it was removed and presumably destroyed in 1796.

The last 18 years of Gilbert's life were occupied with the writing of his great work *De Magnete*, first translated from the original Latin into English by Dr. P. F. Mottelay in 1893, and independently by the Gilbert Club in 1900 in honour of the tercentenary of the original publication. The full title of Gilbert's book describes its contents:

ON THE MAGNET, MAGNETICK BODIES ALSO, AND ON the great magnet the earth; a new Physiology, demonstrated by many arguments & experiments.

Gilbert experimented ceaselessly with metallic and non-metallic materials, and found, for example, that whereas a sheet of iron would form a screen against magnetism, other metals and non-metals would not. He discovered that heat would destroy magnetism, and that hammering an iron bar on an anvil placed north to south would cause it to be magnetized. Fig. 3, taken from *De Magnete*, shows this operation being performed by a smith facing the north.

3 *Magnetizing a bar lying on the meridian*

In his experiments Gilbert used a terrella, or globular lodestone, to represent the earth, and from his observations "he advanced the entirely novel idea that the globe of the earth is itself a great magnet, thus laying the foundations of the science of Terrestrial Magnetism."[2] Another discovery of William Gilbert was the means of augmenting the power of a lodestone by providing it with what he termed an "armature," or soft iron cap over each pole. This earned him the praise of the renowned Galileo, who wrote of him: "I extreamly praise, admire and envy this Authour, for that a conceit so stupendious should come into his minde. . . . I think him moreover worthy of extraordinary applause for the many new and true Observations that he made."[3]

Gilbert invented the rotating-needle electroscope, which he termed a versorium and used extensively in his experiments. With its aid he plotted the "orbe of virtue" or "magnetic atmosphere" surrounding both the earth and lodestone alike. He correctly discerned that the magnetic field is distributed throughout an iron rod and is not concentrated in its surface.

Gilbert originated the term "equator" and first used, in a magnetic sense, the word "cohere." He gave us the expressions "electric attraction," "electric emanation," and "electric force," which he used to describe the properties of amber, sealing wax, and similar bodies, which he called "electrics." Great was his fame and permanent the impact of his work upon science. Truly could Dryden write a century later:

Gilbert shall live till loadstones cease to draw
Or British fleets the boundless Ocean awe.

The publication of *De Magnete* in 1600 gave rise to much speculation, but little effective progress was made until about 1746–47, when Dr. Gowin Knight, M.D., F.R.S., invented a method of making powerful permanent magnets. Dr. Knight (1713–1772) was indeed a man of parts. Qualified in medicine, he became in 1756 the first Principal Librarian of the British Museum, and held this office for the rest of his life. Gowin Knight constructed two large magnets for the Royal Society, each consisting of 240 tempered steel bars, about 15in long, 1in wide, and $\frac{1}{2}$in thick. They were in use for many years, and in the early 19th century were rebuilt to form one large compound magnet, which is now in the Science Museum. It was this magnet which Faraday used "at the house of Mr. Christie" in the famous experiment of 1831. Knight was granted the first English patent in the subject class "Electricity and Magnetism," being No. 850 of June, 1766, and relating to a new method of constructing the mariner's compass. According to Esdaile[4] ". . . he engaged in invention and speculation . . . Inevitably he fell into money difficulties and . . . died in debt, fortunately without scandal"! The method devised by Dr. Knight for making artificial paste magnets was published in 1779, some years after his death.[5]

In July, 1792, Patent No. 1891 was granted to William Fullarton of Fullarton, Ayrshire, bearing the title "Invention and Discovery of certain New Methods of Separating Iron and Iron Stones. . . ." According to the specification, the iron stones would be ground or

stamped, and passed through sieves where necessary. "In the next place to separate all earthly, impure and extraneous matters from the metallic particles by all or any of the following methods . . . and by the application of magnetic attraction." This would appear to be the first recorded instance of the practical application of magnetism to industry and is therefore of great interest. As was usual in those days, the specification gives no description of the mechanism employed.

Early Electricity

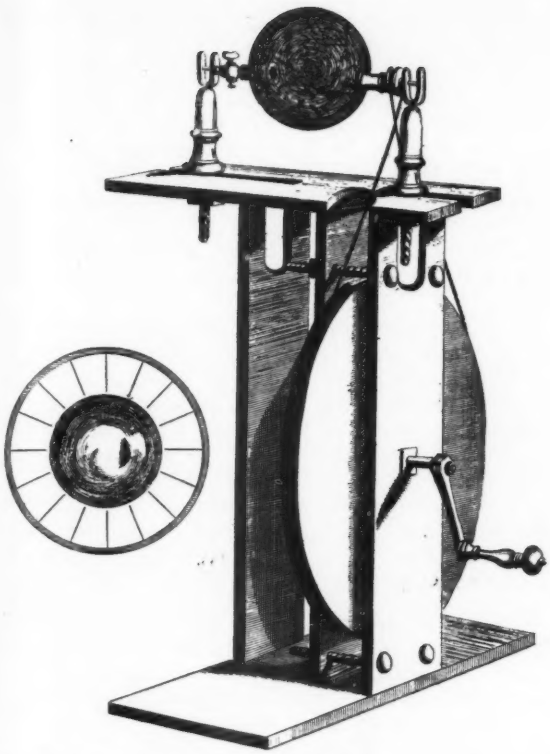
In Chapter 2 of Book II of *De Magnete*, Gilbert summarized all that was known of frictional electricity produced by rubbing amber, jet, and similar substances. The next decisive step in the development of this branch of the science occurred in 1672 when a German physicist published an account of the first frictional machine.[6] He was Otto von Guericke (1602–86), sometime Burgomaster of Magdeburg. The "machine" consisted of a cast sulphur ball and the means for rotating it, using a hand as the collector. The fine portrait of von Guericke reproduced in Fig. 4 is taken from his book, in which also appears the famous sulphur ball (Fig. 5). Von Guericke is credited with being the first experimenter to note that an electrical discharge produced sound and that it was also luminous. His work was intermediate between the purely manual experiments of Gilbert with "electric" bodies, and those of Francis Hauksbee the Elder, who about 1709 employed a glass cylinder (as first proposed by Sir Isaac Newton) and observed within it a glow when the glass was touched by the hand during its rotation. Hauksbee's illustration of his machine is shown in Fig. 6. On the left of the glass sphere there is a connection for a vacuum pump.

4 *Otto von Guericke, 1602–86*

5 *Von Guericke's sulphur ball*

In Britain the Royal Society (founded about 1645 as the Invisible College on a pattern suggested by the "New Atlantis" of Francis Bacon, and later incorporated by the Charter of King Charles II in 1662 under its present title) has held regular meetings in London for the interchange of knowledge from a variety of sources "communicated" through a Fellow, as well as from original papers. Many such Communications were, from its beginning, recorded in the Society's journal, *The Philosophical Transactions*, which soon achieved a world-wide reputation. On the Continent, the Academies of Florence (1657), Paris (1666) and Berlin (1700) were conducted on somewhat similar lines, and much of the early experimental work was carried out by members of these societies in their respective countries.

Although Sir Isaac Newton contributed little directly to electrical science, we must acknowledge his conception of an all-pervading medium, aether,[7] to which further reference will be made in later articles. He was President



6 *Hauksbee's influence machine, 1709*
Note the absence of a prime conductor. The small illustration represents the sphere surrounded by a hoop with threads attached.

of The Royal Society for a period of 24 years from 1703 to 1727, a record equalled or surpassed only by that of Sir Joseph Banks (President, 1778–1820).

Stephen Gray, F.R.S., a pensioner of the Charterhouse about 1720–30, repeated and extended Hauksbee's experiments. He clearly recognized the insulating properties of certain bodies, and with their aid demonstrated the transmission of the discharge from an electrical machine over distances exceeding 800ft.

Much work was done with influence machines during the successive years, leading to the invention in 1745–46 of the condenser, long known as the Leyden jar. This discovery, claimed by experimenters working independently in Holland and Germany, was taken up immediately in all parts of Europe. Thus early in 1747 a group of English scientists established the transmission of an electrical discharge from a Leyden jar by wire across the Thames, and again at Shooters Hill on the 5th August, 1748, over some 2½ miles of wire with a return via the earth.

Whilst several experimenters in the early years of the 18th century had speculated upon the similarity between the electrical discharges from their apparatus and lightning, it was Benjamin Franklin (1706–90) who in 1751 first established their identity in a series of daring experiments with kites.[8] His work found immediate application in lightning conductors, and this surely constitutes the first instance of the practical application of electrical science. Franklin's kite experiments were repeated in several European countries, but not always with success! It is recorded that Professor Richmann of St. Petersburg was electrocuted by lightning in his laboratory during a thunderstorm in 1753.

To Franklin is generally attributed the prior use of the terms "positive" and "negative" as applied to electricity, although it is fair to say that the honour must be shared with Dr. (later Sir) William Watson, M.D., F.R.S., who employed them in a Communication to the Royal Society before Franklin's opinion on the subject was known in England.[9] Franklin also refers in his letters from America to "your European Electricians," thus implying that the word was in general use at this time, in its original sense of one skilled in electrical science.

In 1753 John Canton, the inventor of the pith-ball electrometer, repeating and extending the experiments of other investigators with a frictional machine, demonstrated that he could produce positive or negative electricity from the same glass tube, according to the material with which it was rubbed. It is claimed on his behalf that he was the first to establish "the fundamental fact of electrification by induction."

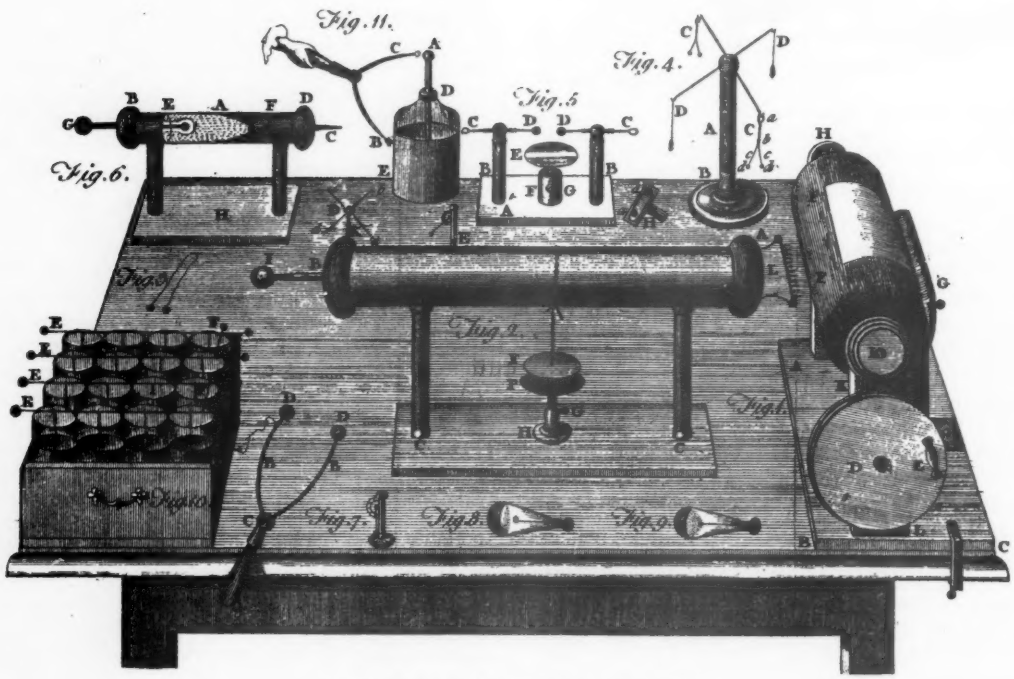
It was on the advice of Benjamin Franklin that Dr. Joseph Priestley, F.R.S. (1733–1804), published in 1767 his book called "The History and Present State of Electricity," in which he reviews the work of the early investigators, thus becoming the first historian of electrical science. Priestley was involved in the first "battle of the systems," which arose in this way. About 1770 the question of lightning conductors was receiving considerable publicity. A Committee of the Royal Society, including amongst others John Canton, Benjamin Franklin, Sir William Watson, M.D., and Benjamin Wilson (all "electricians"), was appointed to advise on the most effectual way of protecting St. Paul's Cathedral, the steeple of St. Bride's Church nearby having been struck and seriously damaged. The Committee decided in favour of the pointed conductors advocated by Franklin. In 1772 it was learned that some powder magazines in Italy had been struck, and at the instance of the Board of Ordnance a Committee was appointed to consider means for protecting the magazines at Purfleet. This Committee included Henry Cavendish, Franklin, Watson and Wilson and reported in favour of pointed conductors, Wilson dissenting. The Government accepted the majority report and fitted pointed conductors, but in 1777 the magazines were struck and slightly damaged.

The matter was once more referred to the Royal Society for advice, and a new Committee, which included W. T. Henley and Edward Nairne, was appointed. These gentlemen examined the building and again favoured pointed conductors. Benjamin Wilson, F.R.S. (1708–88), painter to the Board of Ordnance and a

student of electrical physics (he was the author of small treatises), was not a member of the new Committee, but he put forward an independent report advising the Board in favour of the use of blunt conductors, based upon his own experiments. Wilson's report was referred to the Society, which thereupon appointed Cavendish, Henley, Nairne, Priestley and others to consider it, the findings being in favour of pointed conductors as before. Wilson then informed the Board that this report did not reflect the view of the Society as a whole, and the President, when asked for an explanation, stated that it was never the Society's practice to give its opinion as a body at large, but always by selected committees, and in this instance he had no reason to be dissatisfied with the report of the Committee. England was at war with the States of America, for whom Franklin was European representative, and so the issue became one of politics and reached Court circles. According to Weld,[10] the King supported Wilson against the views of Sir John Pringle, whom he pressed to use his influence to reverse the decisions of the Committee. It was on this occasion that Pringle is said to have replied: "Sire, I cannot reverse the laws and operations of nature." Weld states that this led to the resignation of Pringle in favour of Sir Joseph Banks, who, as already noticed, was elected President in 1778.

The new President, not being concerned in the matter, was able to refrain from taking sides, but evidently felt that something was due to Franklin, whose reputation had been slighted. Sir Joseph rectified this some years later when he persuaded the King to include Franklin among the recipients of a presentation edition of Hawksworth's official accounts of Captain Cook's voyages. Priestley left England for America after the destruction of his house in Birmingham during the Church and King Riot in 1791.

By the latter part of the 18th century the discoveries of the "philosophers" had aroused widespread interest in electrical science. Work on the influence machines began to assume a quantitative outlook, and in 1772 William T. Henley, F.R.S. (died 1779), invented a quadrant electrometer whereby the quantity of electricity stored in a Leyden jar could be measured through the repulsion produced by the charge on a pith or cork ball, suspended from the centre of a graduated scale. He thus became the inventor of one of the first electrical measuring instruments. The influence machine was vastly improved by Edward Nairne, F.R.S. (1726–1806),



7 *An electrician's laboratory, about 1782*

The illustration, which is reproduced from the "Complete Treatise of Electricity," by T. Cavallo (Second edition, 1782), includes the following:

Fig. 1. Cylindrical influence machine
Fig. 2. Prime conductor with Henley's quadrant electrometer (E)
Fig. 4. Stand of electrometers of various types
Fig. 5. Henley's universal discharger
Fig. 7. Henley's quadrant electrometer
Fig. 10. Battery of Leyden jars
Fig. 11. Simple Leyden jar, with discharger

an optician and scientific instrument maker of Cornhill; he was granted the third electrical patent, being No. 1318 of February 1782, relating to "new invented and most usefull [*sic*] improvement in the common electrical machine, which I call the insulated medical electrical machine."

According to Cuthbertson,[11] the machine was originally made in 1774 and was of the glass cylinder type. It was far more powerful than any of its predecessors, and in his experiments Nairne employed with it a battery (a set of Leyden jars) with a coated surface area of 50 square feet. This machine was extensively figured in many books on physics and mechanics of the period and remained little changed until the time of Wimshurst (about 1880). Nairne's cylinder machine is shown in Fig. 7, together with a quantity of apparatus in general use towards the end of the 18th century.

It has been stated that the work of Coulomb (1736–1806) in the realm of experimental electricity paved the way for the more elegant work of Volta. Coulomb's torsion balance, details of which were published in 1784–85, enabled him with certainty to enunciate the basic laws of magnetic and electrical attraction and repulsion, which had been put forward in a tentative hypothesis by Professor Michell of Cambridge in the year 1750. Coulomb's work lacked popular appeal and was thus overshadowed by the more spectacular results described in "Electricity of Metals" by Professor Galvani of Bologna (1737–98), which was published in 1786.

One of the best remembered names among the early experimenters is that of Professor A. Volta (1745–1827) of the University of Pavia, who in 1769 recorded his experiments with a metal-plate condenser having a resin dielectric; it became known later as Volta's electrophorus. This and other discoveries earned him the Copley medal of the Royal Society, but undoubtedly his invention of the voltaic pile—comprising alternate discs of copper and zinc which were separated by insulating material soaked in an acid electrolyte—eclipsed all other electrical discoveries of the 18th century. The pile or battery was made in 1796 and first announced in 1800 in a letter to Sir Joseph Banks, by whom it was communicated to the Royal Society on June 26th of that year.

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TECHNICAL PUBLICATIONS

BRITISH STANDARDS

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1.

ELECTRICITY METERS (B.S. 37: Part 4: 1954). 3s. (POST FREE).

This new Part of the revision deals with certain motor-type integrating meters and applies to polyphase whole-current and transformer-operated meters, single-phase, 3-wire whole-current and transformer-operated meters, and single-phase 2-wire transformer-operated meters.

Provision is now made for the higher-rating meters to register in megawatt-hours; and standard connections are now specified only for front-connected whole-current meters (without self-contained current transformers) having terminals at the bottom.

DEFINITIONS FOR USE IN MECHANICAL ENGINEERING (B.S. 2517: 1954). 6s. (POST FREE).

The aim of this Standard has been to provide a logical code of definitions which are both clear and consistent; general use of the various terms in the sense in which they are here defined should go far to obviate misunderstandings. No less important, perhaps, is the fact that students encouraged to use the code will find it of great assistance to them in their appreciation of the theoretical conceptions on which all practical engineering is based.

The definitions given relate to terms of general application in the engineering industry, and more particularly in mechanical engineering. The eight sections of the Standard relate to construction, drawings and schedules, geometry of parts, size and tolerances, limits and fits, screw threads, surface texture, and gauges.

AIR-COOLED FLAMEPROOF SINGLE-PHASE LIGHTING TRANSFORMER UNITS SUPPLIED FROM HIGH-VOLTAGE SYSTEMS. (B.S. 2538: 1954). 2s. (POST FREE).

This Standard applies to air-cooled flameproof single-phase lighting transformers supplied from high-voltage systems and complete with protective fuses and primary isolating switch. The transformers are intended mainly for the lighting of roadways in coal mines, but they may also be used in other places where inflammable gas or vapour may be present in the surrounding atmosphere.

THE PRESIDENT'S ADDRESS

Energy and its challenge

AN ABSTRACT OF THE INAUGURAL ADDRESS DELIVERED BY THE PRESIDENT, MR. J. ECCLES, C.B.E., B.SC., BEFORE THE INSTITUTION ON THE 7TH OCTOBER, 1954. THE FULL ADDRESS WILL BE PUBLISHED IN BOTH PART A AND PART B OF THE PROCEEDINGS.

EACH year in this country we consume some 200 million tons of coal, about half of which is used to produce mechanical and electrical power. Assuming a realizable efficiency of conversion from coal to usable power at the point of application, we find that 100 million tons of coal used in this way will do the work of at least 750 million unaided men working a 44-hour week for 50 weeks. The population of this island is rather less than 50 millions, and hence, by the conversion of this amount of coal into work, we have endowed each man, woman and child with 15 slaves to do his bidding. A similar calculation shows that the present home consumption of liquid fuel provides the equivalent of a further five slaves for each living soul in Great Britain. How then has it come about that each of us has to depend upon 20 inanimate slaves to maintain his present standard of mobility, comfort and leisure? For how long has this been going on, and what are the chances of its continuance? These are some of the vital questions of our age, and in attempting to answer them I shall begin by tracing the history of mankind from earliest times.

About 300 million years ago there seems to have occurred upon this planet a condition conducive to luscious vegetable growth over large tracts of its swampy surface. Vegetation grew and decayed until there was built up stratum upon stratum of hydrocarbonaceous matter. To this process we owe the coal measures and oil wells which to-day provide 85% of the world's fuel.

For a very long time after they appeared on the earth, men remained gatherers as distinct from producers. Later they assumed a more active role and endeavoured to improve upon nature by tilling and fertilizing the soil, using domesticated animals for work and food, and fashioning tools of stone and metal. It was in this second phase that the demand for fuel grew apace. Wood was required for warmth, for cooking, and for smelting metal. Large areas in India, China and other countries were deforested to provide wood-ash as a fertilizer, and when, in these areas, crops failed through lack of further enrichment of the soil, the population was decimated by starvation. The record of these early civilizations seems to show that an improvement in technology encouraged the population to increase above the level that could be fed and clothed. Thus it was that lack of knowledge of what nature held in store, and lack of knowledge of how to use efficiently the known resources, caused cultures of high rank to wither.

In some areas, improving supply technology, aided by slave labour, was able to meet the increasing demand for long periods. By 6000 B.C. men began to tap the fossil fuels, beginning with asphalt, and by 4000 B.C. skilful metalwork was being carried out by the Chaldeans. Enamelled pottery was made in Egypt by 3000 B.C., whilst asphalt was employed for waterproofing buildings and for road making. The Chinese used natural gas for fuel about 1000 B.C., and an oil well was in operation on the Island of Zante in 400 B.C. The earliest recorded use of coal is 1100 B.C. in China, and there is evidence that coal was known and used in Britain before the Roman occupation.

Around 500 B.C. there began a period of 2 000 years of technological stagnation, in which little progress was made in establishing man's command over nature. This period included the great Greek and Roman civilizations, which hardly attempted to revive fuel technology. No one knew how to harness nature continuously on the scale necessary to suit the growing human need.

In the 15th, 16th and 17th centuries A.D., science and technology slowly awakened and faced the prejudices which had become entrenched in men's minds, without opposition, during the long period of scientific hibernation. It was in this setting, at the very end of the 17th century, that an Englishman, Thomas Savery, invented the first successful steam engine, and showed how heat could be converted to work. By means of this engine, improved by Newcomen and Watt, there was tapped an enormous reservoir of energy which had been stored in the coal measures for 300 million years. It was natural that the first applications of steam engines should be for pumping and winding at coal mines, but, once this main source of energy had been made secure, their use became general. In 1827 the first steamship crossed the Atlantic to the New World, and in 1829 the first steam-driven railway locomotive was in operation. In 1884 Charles Parsons invented the first practical steam turbine, which so raised the sights in size and efficiency that to-day single machines are being designed for an output of 200 000 kW, using only three-quarters of a pound of coal per kilowatt-hour. Contemporary with these events, work was in progress on the use of oil and gas to obtain mechanical power. The invention of the internal combustion engine was the culmination of these efforts.

The result of these inventions, allied with Faraday's discovery in 1831 of the principle of electromagnetic induction, is that man has, during the past 250 years, developed a method of living that transcends everything hitherto achieved, but which largely depends upon the use in enormous quantities of natural energy stored in a bygone age.

Turning from the past to the present, we find that coal, oil and natural gas are wasting sources of energy. They will eventually cease to exist; for example, it has been estimated that the readily accessible coal remaining

in this island will be exhausted in about 200 years. A recent American assessment of the world reserves of all fuels is shown in the Table. This estimate suggests that

Fuel	World reserves	Source of data	Total energy, B.Th.U.
			$\times 10^{18}$
Crude oil ..	610×10^9 barrels	Weeks and Moulten	3·5
Natural gasoline	$11{\cdot}5 \times 10^9$ barrels	American Petroleum Institute	0·07
Shale oil ..	620×10^9 barrels	Bureau of Mines	4
Natural gas ..	560×10^{12} ft^3	American Gas Association	0·6
Coal	$3\,482 \times 10^9$ tons	Bureau of Mines	72·2
Total conventional fuel			80
Uranium ..	25×10^6 tons	Raw Materials Division of A.E.C.	1 700 at 1 : 1 breeding
Thorium ..	1×10^6 tons	do.	71
Total new fuel (say)			1 800

The Table is reproduced from CISLER, W. L.: "Economic Evaluation of the Industrial Use of Atomic Energy" (American Power Conference, March, 1953).

the world reserves of crude oil are only about 5% of the world coal reserves, whilst, with 1 : 1 breeder reactors, the potential energy of nuclear fuel is more than 20 times as great as that of the world reserves of coal, oil and natural gas together. Of the fossil fuels, oil will be the first to go. Considerable resources of coal exist in some under-developed countries in which its present use is negligible. On the other hand, highly developed countries are consuming coal at a rate disproportionate to their reserves. The reserves of coal are, however, sufficient to allow time for the orderly development of alternatives.

To the question of an alternative to fossil fuels the usual answer is nuclear fuel, but it would be wrong to give the impression that it is a simple answer. Hitherto, heat has been obtained by amputating and regrafting the limbs of matter; in nuclear fission it is proposed to tear out and divide its heart.

The growing population of the world is an important factor in the future fuel situation. The fate of previous civilizations has been sealed when their populations outstripped the ability of their technology to provide sustenance and shelter, and the fate of our own civilization cannot be dissociated from this influence.

I shall discuss the future from two points of view—one on the assumption that nuclear fuel will not prove to be a practical means of providing power, and the other on the assumption that it will. With nuclear fuel counted out, the main alternatives to fosssil fuels will be water power, tidal power, wind power, wood, peat, and animal wastes, together with solar energy and geothermic heat in certain areas.

Hitherto, the assessment of world inland water-power resources has included only those which show prospect of economic development, but in future many more may be pressed into service. The most recent estimates show that the world total of inland water power, 40% of which is in Africa, can supply at least three-quarters of man's present energy requirements. As an example of the kind of project which might have to be undertaken, the water lost from the Mediterranean by evaporation is not wholly recovered from its river inflow, and the consequent inflow from the Atlantic could be made to develop 12 million kW if a differential of 70ft were established.

Since tides follow the moon and man's efforts follow the sun, the tidal cycle is not co-ordinated to human needs, and in this sense tides are an unsatisfactory source of energy. However, there are devices, such as pumped storage and double-basin working, by means of which the energy available for external work can be controlled and better fitted to human requirements. There is also a difference of up to two hours in the time of high tide at different places round our coast. If a powerful electrical transmission system were available to connect all such points it would be possible to take advantage of these time differences to reduce the amount of pumped storage.

The application of wind power depends on the slowing down of air in motion. Because of the low density of the medium, the energy release per unit volume for changes in the speed of air that are likely to be achieved in any practical windmill is quite small. It seems that, although there is a large amount of energy of movement in atmospheric air treated globally, practical considerations will limit the contribution to be made from this source to a small proportion of man's present-day energy requirements.

The amount of solar energy reaching the land areas of the earth's surface is equivalent to 10 000 times man's present requirements, and I suggest that this may be the source which will supply the needs of the final scientific civilization. The low intensity and the daily and seasonal variations prohibit the production of mechanical power by present known methods in any but tropical and subtropical regions.

Apart from nuclear fission, the most reliable and economical alternative to coal and oil is water power, but its disposition on the earth will demand either fantastic power transmission schemes or else a considerable shift of population.

Turning to the possibilities of nuclear power, we may recall Professor Einstein's calculation that the annihilation of one pound of matter would release energy equal to 11 340 million kWh of electricity. No means has yet been found to achieve this result. It has been possible, however, to release a tiny fraction of the mass energy of matter by persuading a heavy atom to divide into two lighter atoms, whose combined mass is a little less than that of the heavy one. Similarly, it has been possible to release energy by persuading a number of light atoms to form a single atom whose weight is a little less than the sum of the weights of the lighter atoms that combine to

make it. The division of uranium into two lighter elements or the fusion of hydrogen into helium offers the possibility of energy release. Since hydrogen constitutes a substantial proportion of the earth's crust, the potential energy from the hydrogen–helium fusion process could be enormous. The industrial application of this great energy source will depend upon the discovery of something which will enable the reaction to proceed at a lower sustained temperature than is necessary at present.

It seems probable that the fission of uranium can be controlled in such a way as to liberate heat at a temperature suitable for industrial power purposes. Before large-scale nuclear power stations can become practicable, however, work must be done on heat-transfer methods and materials and on the treatment of fission products.

Of the uranium existing in nature, only about 0·7% is fissile, but a process has been devised by which the remaining 99·3% can be converted into plutonium, which is fissile. Thus it is now possible to release all the energy content of the uranium, and perhaps of the thorium, in the earth's crust. It has been estimated that the availability of uranium is such that an expenditure of £50 per pound of pure metal should be sufficient to provide enough fuel to meet man's present annual energy requirements for 1500 years. On the same basis, an expenditure of up to £100 per pound of pure metal should provide sufficient fuel to last another 8 500 years. The separation and purification of uranium consumes a considerable amount of energy, but local surpluses of water power may well be used to purify fissile material so as to provide power in lands where alternatives are insufficient. And since fissile material is easily transportable, this may solve the power transmission problem.

Unless man is able and willing to match his technology to the unfolding needs of the situation, he has no prescriptive right to a continuance of his latest civilization. The history of civilization discloses that discontinuity—decay and rebirth—is the normal method by which successive stages in civilization have been reached. To-day, however, man is equipped with a knowledge of natural laws (science), and an ability to harness these laws (engineering) that were absent in all previous civilizations, and there is good reason for thinking that the present mode of living can be greatly prolonged if he will but use this knowledge and ability aright. The test is one of competence, in the political sense to learn how to live together in peace, and in the technical sense to unravel the unsolved relationships in nature and to constrain them to serve the ends of mankind. These twin challenges must be met if civilization is to endure.

SECTION CHAIRMEN'S ADDRESSES

SUMMARIES OF THE ADDRESSES OF THE CHAIRMEN OF THE SPECIALIZED SECTIONS

MEASUREMENTS SECTION

Electricity Meters

THE ADDRESS WAS DELIVERED BY THE CHAIRMAN, MR. M. WHITEHEAD, BEFORE THE MEASUREMENTS SECTION ON THE 19TH OCTOBER, 1954. AN ABSTRACT OF IT WILL BE PUBLISHED IN PART A OF THE PROCEEDINGS, FEBRUARY, 1955.

The basic unit from which all present-day metering stems is the single-phase induction watt-hour meter, which is numbered in many millions throughout the world. On this type of meter depend very largely the commercial transactions between suppliers and users of electricity. Superficially it is the most simple of devices but its analysis is extremely complex and highly mathematical. However, a physical and descriptive treatment is to some extent possible.

The ratio of maximum to minimum current over which acceptable and stable performance is obtained is important. It is easy to make a meter have an apparently long range by careful adjustment at low loads only to find that the low-load error is variable. Long experience has shown that a stable lowest load is associated with a driving torque at this load of the order of 0·2g-cm.

The development of measuring range is illustrated in the Table. It relates to electricity meters which have been made in large quantities and have a torque of not less than 0·2g-cm at minimum load. The measuring range is that in which the error is never more than 1%.

Measuring Range of Meters with Current as Sole Variable

Year	Range (fraction of nominal load)	Ratio max/min
1910	$\frac{1}{20} - \frac{3}{2}$	30
1920	$\frac{1}{20} - \frac{7}{4}$	35
1930	$\frac{1}{20} - \frac{3}{1}$	60
1940	$\frac{1}{20} - \frac{4}{1}$	80
1950	$\frac{1}{20} - \frac{5}{1}$	100

A discussion of the economics of metering invariably raises the suggestion that the use of meters should be avoided altogether. It has been convincingly argued, however, that the very existence of a supply system depends upon them for the prevention of wasteful consumption.

The cost of a watt-hour meter necessarily hinges on the accuracy required from it. In general, the consumer is more concerned with this accuracy than the supply

authority, since any meter will check wasteful consumption, and the random errors in a number of meters tend to offset each other.

I suggest that the economic cost of a meter ought to be decided on the basis that a consumer's payment should be a minimum, assuming the meter to be set at the positive limit of error. With the aid of an assessed scale of total metering cost in relation to accuracy level, it is possible to determine the consumer's total payment for any given cost of energy consumed. If this total payment is plotted against accuracy level, the curve exhibits a minimum point, which is the economic level of accuracy for the particular consumption of energy.

RADIO SECTION

New Materials and the Electrical Engineer

THE ADDRESS WAS DELIVERED BY THE CHAIRMAN, MR. C. W. OATLEY, M.A., M.SC., BEFORE THE RADIO SECTION ON THE 13TH OCTOBER, 1954. AN ABSTRACT OF IT IS PUBLISHED IN PART B OF THE PROCEEDINGS, JANUARY, 1955.

During the past 30 years the introduction of new materials has brought about great changes in radio engineering. This is true of dielectric and magnetic materials, but the greatest changes have been caused by the utilization of new conductors, if this term is used rather loosely to include electron streams and gaseous discharges. At the present time we appear to be at the beginning of a new era of development in which the potentialities of conduction in non-metallic crystals will be fully exploited. The recent introduction of the various types of transistor has revealed the possibilities of devices of this kind, but non-metallic conduction is also playing other important parts in the development of radio engineering.

Non-metallic crystals are normally regarded as insulators, but if sufficient energy is communicated to some of the more loosely bound electrons which a crystal contains, in order to free these electrons from their parent atoms, the electrons can move freely through the lattice and the crystal will conduct. The situation is in some respects analogous to that which exists in a gas. Normally the gas is an insulator, but if some of its atoms can be ionized by an external agency, the motion of the electrons and ions so formed will cause the gas to conduct. In a non-metallic crystal the part of the positive ions is played by positive holes, or sites from which an electron has been removed. There are, however, many important differences between conduction in gases and that in non-metallic crystals. For example, the latter is affected to a much greater extent than the former by the presence of impurities.

In certain non-metallic substances the necessary energy to ionize some of the atoms can be supplied in the form of heat. Such substances are semi-conductors and have a negative temperature-coefficient of resistance, since the warmer they are the more free electrons they will contain and the better they will conduct. These materials find practical use as thermistors. Furthermore, the contact between some semi-conductors and metals gives rise to a non-linear resistance, and this property is used in copper-oxide and selenium rectifiers.

Alternatively, the ionizing energy may be supplied in the form of radiation. An early example of this was the selenium cell which became conducting under the action of light. More recent applications are in photo-conductive cells for infra-red detection and in one type of television camera tube. Closely allied to ionization caused by the absorption of radiation is that caused by the impact of swiftly moving electrons. Non-metallic conduction produced in this way plays a fundamental role in the mechanism of the luminescent phosphors used in cathode-ray tubes.

These and other examples illustrate the importance to the radio engineer of a knowledge of the principles of non-metallic conduction. Some means must be found of enabling him to study this subject during a university career if he wishes to do so.

SUPPLY SECTION

1910–1954

THE ADDRESS WAS DELIVERED BY THE CHAIRMAN, MR. J. D. PEATTIE, B.SC., BEFORE THE SUPPLY SECTION ON THE 27TH OCTOBER, 1954. AN ABSTRACT OF IT WILL BE PUBLISHED IN PART A OF THE PROCEEDINGS, FEBRUARY, 1955.

In 1910, Dr. Ferranti, in his Presidential Address to The Institution, set out proposals for the development of the electricity supply industry. He took as a basis those energy requirements which were being met in 1903 by a home consumption of 150 million tons of coal, and he proposed that they should be met by the conversion of 60 million tons of coal into 131 400 million kWh of electrical energy. This amazing suggestion was made at a time when we were converting between only 1% and 2% of the total home consumption of coal into electricity.

Man's existence at his present standard of life depends on the use of energy during its accelerated conversion from the highest grades, concentrated in the mass of fuels, to the lowest grade of heat. Electrical energy, which is a comparatively new link in the conversion process, is unique. It fulfils a requirement of Ferranti in that it is the form generally applicable to all purposes without exception. At the same time, it is most difficult to waste.

In the 12 months ended 30th June, 1954, B.E.A. stations consumed 37·2 million tons of coal and sent out 63 000 million kWh of electrical energy—about half Ferranti's estimate of the total to meet Britain's requirements in 1903. Since 1903 these requirements have increased, owing to the growth of population and the greater consumption of energy per head of population.

For lighting and power, the electrical link in the con-

version of energy is supreme. Controversy rages over heating, but conditions are moving in favour of electricity, as special coals become more difficult to obtain and nuclear fuels are developed. In connection with the use of electricity for heating, I would call attention to the suggestion that it should be employed in iron smelting, the coke being reserved for chemical action only.

A widespread network of electrical transmission and distribution systems now exists in this country, and it is inherently capable of easy extension and increase in capacity to meet consumers' ever-increasing demands. After post-war difficulties, generating station capacity is nearly equal to the present demand and is being steadily augmented. The average efficiency of 23·54% is close to Ferranti's figure of 25%, and this will be passed in a year or two. Sizes of generating units and boilers are increasing proportionally to demand, and 200 MW sets with appropriate single unit-boilers are planned for 1959 and later. Plant is being provided for the supply in 1965 of 120 000 million kWh from B.E.A. stations.

Development is always attended by difficulties. At present, difficulties in provision of cooling water and in control of atmospheric pollution are much in evidence. We are solving these problems, as we shall solve other problems which will arise in due course with nuclear fuels.

Arguments that saturation in demand will occur sooner rather than later do not explain the absence of signs of saturation in countries like Canada and Sweden, with consumptions per head of population respectively three-and-a-half times and twice that of Great Britain. There is every reason to believe that the demand for electricity in Great Britain will double approximately every ten years for decades to come.

Reserves of stored energy, particularly in nuclear fuels, are very large. Mankind is demanding the use of more and more of that energy as it passes from its higher to its lower forms. Until the demand subsides, or until some better link than electricity in the conversion chain appears on the scene, The Institution, and in particular the Supply Section, must help towards meeting that demand.

UTILIZATION SECTION

Educating the Public

THE ADDRESS WAS DELIVERED BY THE CHAIRMAN, MR. J. I. BERNARD, B.SC.TECH., ON THE 21ST OCTOBER, 1954. AN ABSTRACT OF IT WILL BE PUBLISHED IN PART A OF THE PROCEEDINGS, FEBRUARY, 1955.

Col. R. E. Crompton in his Presidential Address to The Institution in 1895 said, "Not the lightest of the duties of the modern electrical engineer is that of educating the public in the use of electrical energy." I suggest to-day that engineers, in addition to designing and making apparatus, should explain to users what such apparatus will do for them. In the field of industrial productivity, the figures for installed horse-power give some indication of the method of production, and the figures for units of energy used indicate the quantity of production. In the United States the energy used in production rose from 4½ kWh per man-hour in 1939 to nearly 7 in 1950 and the aim is to raise the figure to 10 by 1960. In Britain the present consumption is only about 2 kWh per man-hour. However, the increasing use of equipment such as automatic transfer machines, mechanical handling plant, and induction- and dielectric-heating apparatus, will raise this figure. Over 90% of high-grade brass is now melted electrically, and there is a growing use of arc furnaces for melting and refining scrap, and of high-frequency induction furnaces for making tool steel. Electrical methods of measurement or inspection should be more widely employed to release operatives from repetitive routine work. In commercial buildings thermal-storage electric heating ought to be better known, in the form of either floor heating by embedded cables or storage block heaters.

In the domestic field the post-war development of British-made appliances, and the prospect of an unrestricted supply of electricity at a favourable price, augur well for a continuation of the expanding consumption of electricity which has been taking place in the last ten years. The latest types of cooker include refinements such as quick-boiling radiant hot-plates with continuously-variable control switches and a time switch so that the cooker will cook a meal by itself. For electric water-heating the two-in-one self-contained heater is the ideal form of hot-water supply for flats, while immersion heaters can be used economically in houses supplied with solid-fuel-fired boilers, provided that the storage vessel is properly lagged. A wide variety of washing machines is available, and the efficiency and reliability of British-made refrigerators have been further improved by the introduction of hermetically sealed compressor systems.

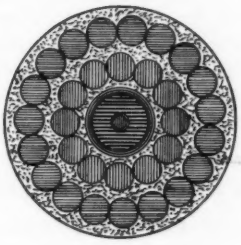
The value of thermostats for the control of low-temperature heaters such as convectors, liquid-filled radiators and radiant panels, which are made in a wide variety of designs, is being more and more recognized, but there seems little likelihood of the employment of structural heat insulation of buildings to a standard high enough to enable all-electric heating to be used at no more cost than solid-fuel heating.

In domestic appliances shaded-pole motors are tending to replace the commutator type because of the need to suppress interference with radio. Where commutators are necessary on account of their higher speeds, mainly in vacuum cleaners, interference suppression has been simplified by the introduction of double-insulated construction, which permits larger capacitors to be connected to the motor frame without increased risk of shock.

The electrical industry as a whole has not made its weight felt in getting public opinion to regard an adequate number of socket-outlets as part of the essential equipment of a house. Members of The Institution ought to lose no opportunity of extolling the convenience of the "universal" flat-pin 13 amp socket-outlet.

The Transatlantic Telephone Cable

Type A cable, of overall diameter 1·84 in



Type AA cable, of overall diameter 2·68 in

Great interest has been aroused by the announcement a year ago that a telephone cable is to be laid across the Atlantic. Both on account of its obvious merit, and as the heirs of those who founded the Society of Telegraph Engineers when the lustre of the first Atlantic telegraph cable was not yet dull, present members of The Institution have enthusiastically welcomed the plan, and they will surely follow its progress with eagerness. This article is based on the information given at the Ordinary Meeting of The Institution at which an Anglo-American paper on the telephone cable was presented. It is hoped to print articles on the progress of the work in future issues of the Journal.

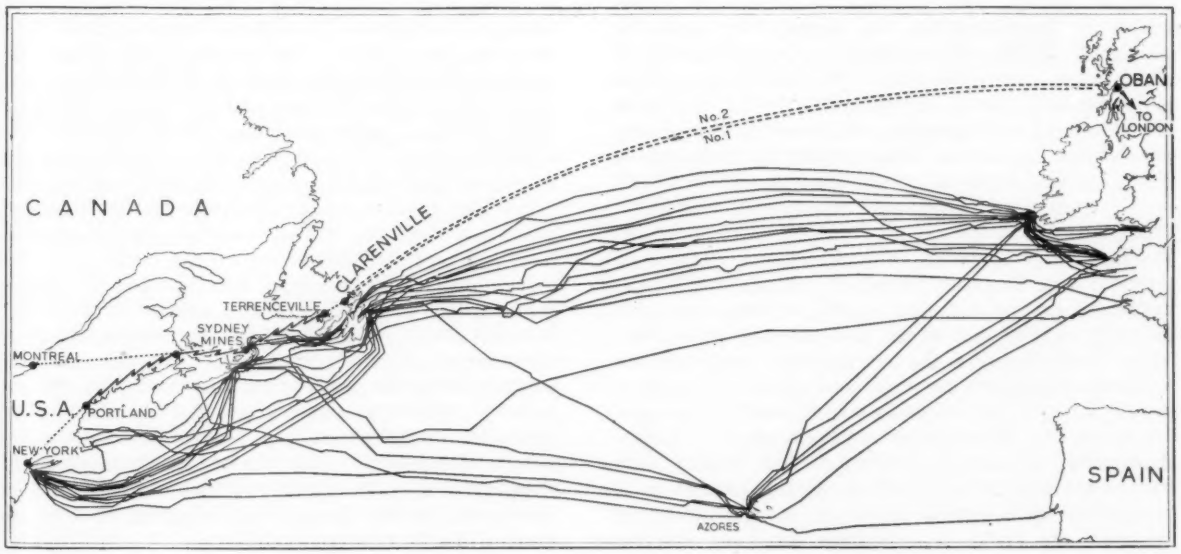
THE North Atlantic Ocean has ever been the proving ground of all major advances in long-distance oversea communication; its conquests by sea, by air, by telegraph cable, and by radio link have been numbered in turn among the greatest achievements of mankind. From the longship of Lief Ericsson in the Dark Ages to the first whisperings carried by radio wave to Marconi at the birth of our own century, this ocean has challenged man into prolonged and often hazardous struggles with the forces of nature. And surely few struggles could have been so prolonged, or pursued in the face of such persistent heartbreak, as the fight to lay and operate the first transatlantic telegraph cable. Brunel's ill-fated dream ship, the *Great Eastern*, began operations in the summer of 1857, but the cable then laid failed after only a few weeks' service; and it was not until 1866 that the courage and determination of Cyrus W. Field of America, allied with the technical brilliance of our own William Thomson (Lord Kelvin), brought this mission to a successful conclusion.

Now the Atlantic is to yield again, to become the first ocean spanned by a telephone cable. Once more it is to be a joint Anglo-American achievement, and it is backed by the combined resources of the British Post Office and the American Telephone and Telegraph Company. And when the British cable ship *Monarch* steams out of Grand Banks waters to begin laying the first cable, she will take with her 30 years' painstaking research and experience. Preliminary details of this project are given in a paper* read before The Institution on the 4th November

* KELLY, MERVIN J., RADLEY, SIR W. GORDON, GILMAN, G. W., and HALSEY, R. J.: "A Transatlantic Telephone Cable."

1 *Cables across the North Atlantic*

———— Existing telegraph cables.
— — — — The new telephone cables.



1954, and soon to be published in Part B of the *Proceedings*; this surveys the many problems set by such a venture and indicates how research and field-test teams on both sides of the Atlantic combined to overcome them. Some idea of the magnitude of the project may perhaps be obtained when it is realized that the longest telephone cable so far laid is that between Scotland and Norway, completed in October, 1954; this is 300 miles long and contains seven submerged repeaters, and so it will be a major step to a cable 1 950 nautical miles long with no less than 52 repeaters. And the Scotland–Norway cable is in quite shallow water. Even the deepest repeatered cable, that between Havana and Key West, never falls more than a mile below the surface, but parts of the route across the North Atlantic will plunge the cable down to a depth of two and a half miles.

The Advantages of the Cable

Why do it if the problems are so great? What can this cable offer which cannot be provided by the telegraph and radiotelephone? Stripped of its technicalities the answer is speed, quality and reliability. Consider the telegraph system, in which every message must be converted into code, transmitted and then decoded. The first cable had a capacity of only three words per minute, so that operation was painfully slow; its bandwidth was only 1·5c/s, so that there was no possibility of the simultaneous transmission of several messages. After nearly a century of effort, spurred by the growing demands for more rapid communication, the bandwidth available on the best telegraph cable is still no more than 100c/s, and the demand for channels has been met by the laying of more cables, until there are now no less than 20 in operation across the Atlantic. By contrast, the telephone cable will have a bandwidth of 144kc/s and will carry 36 telephone channels.

What then is the drawback of radio, for radiotelephonic communication has already been used for 27 years? Briefly, the problems are caused by lack of elbow room and by sunspots. The usable part of the r.f. spectrum is, by its nature, rather limited, and most careful international planning and agreement is necessary to minimize interference between radio transmissions—a host of services have call on the space available. There are 16 transatlantic short-wave radiotelephone links to this country, but there is no room for increase in this number. Again, radiocommunication in the North Atlantic area is much subject to extraterrestrial disturbances, especially during a period of intense sunspot activity, such as that which has persisted since 1950; under these conditions the link may fail completely and without warning, and the break may last for an indefinite period, or until the transmission frequency is changed. There can thus be no guarantee of reliability. A further disadvantage is lack of privacy: a message sent by radio can be received by anyone who cares to tune in to it, so that privacy is possible only when scrambling devices or codes are used. It is perhaps surprising that the service has given reasonable satisfaction for so long in the face of these disadvantages.

The Route of the Cable

So much for the reason why we need a telephone cable. The next problem is where to put it, because, as Fig. 1 (page 25) shows, the bed of the ocean carries many telegraph cables, and it is at least strongly advisable to avoid crossing them. So a northern route shown has been chosen, from Clarenville in Newfoundland to Oban, a distance of 1 950 nauts—telegraph nautical miles—or some 2 240 statute miles. From Oban connection with London and the principal cities of Europe is, of course, easy, for the British Post Office have used the North Sea as a major proving ground for their undersea equipment, and have successfully and adequately linked the British Isles and most Continental countries by telephone.

From Clarenville, a second cable crosses the island to Terrenceville, whence it sweeps across the Cabot Straits to the Nova Scotian port of Sydney Mines. From there a microwave radio-relay system with line-of-sight transmission will carry the signals towards Montreal and New York, into the Canadian and American networks. The factors governing the final choice of route from Newfoundland to the mainland are detailed in the paper, and power-line engineers will be interested to learn that their Post Office counterparts actually prefer to lay their cables in water.

The Pattern of Development

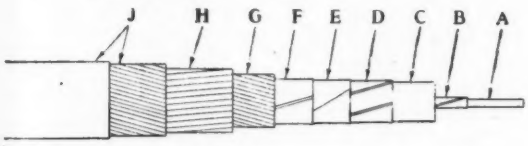
This, then, is the background of the project. The success or failure of the scheme depends largely on two things, the cable itself and the submerged repeaters which make the working possible. · True, plans were laid for an unrepeatered single-circuit cable as long ago as 1928, but the economic conditions of the thirties prevented its realization, and the growth of traffic since then has made the repeaters essential, for without them the cable could carry but one circuit. The guiding light behind the American development has been Dr. O. E. Buckley, who formed his team in 1919 and laid an undersea telephone cable in 1921, in moderately deep water between Havana and Key West. It is interesting to see how local topography conditioned the pattern of development on each side of the Atlantic. The islands around the American coasts are small and the channels are narrow, so that they presented few difficulties; on the other hand, the major undersea transmissions were few and the depths considerable, so that American efforts were always directed to deep-water working. In Europe, however, the waters are relatively shallow, and the distances between Great Britain and the mainland vary from a score to several hundred miles; British efforts were thus concentrated primarily on shallow-water cables and associated repeaters. The two patterns were therefore complementary, although the British Post Office also developed a repeater for operation in depths far exceeding those of the Continental Shelf.

The long-term development of the cable itself took place largely in America, taking as its starting-point the existing deep-sea telegraph cables. Major contributions were made as a result of new developments and laying experience, notable among them being a study of the deformation of the conductors and armour wires during laying and recovery, and the British development of the dielectric polyethylene.

In deep-sea telegraphy it is customary to use the sea itself and the armour wires of the cable as the return medium, but since this is unsatisfactory at frequencies above a few kilocycles per second, for telephony it becomes essential to use a coaxial structure with a copper return conductor. As a result of laying trials the lays of the tapes and armour wires are in the same direction; and since polyethylene proved superior to the dielectrics previously used, it was adopted as the main insulation medium. A cross-section of the cable which will be used at all depths exceeding 700 fathoms is shown in Fig. 2, but heavier armouring will be necessary in shallower waters, where the possibility of accidental damage is greater. The type A cable, shown at the head of this article, is to be laid in depths not exceeding 300 fathoms; type AA will be used for the landings.

2 *The deep-water cable*

A. Centre conductor; 0·1318in diameter copper.
B. Three 0·0145in copper surround tapes.
C. Polythene to 0·620in diameter.
D. Six 0·016in copper return tapes.
E. 0·003in overlapped copper teredo tape.
F. Gapped Telconax tape.
G. One serving of cutched jute.
H. Twenty-four 0·086in diameter high-tensile steel armour wires.
J. Two impregnated-jute servings.



A new factory for the manufacture of the cable was opened at the end of November, and work on the cable is proceeding apace.

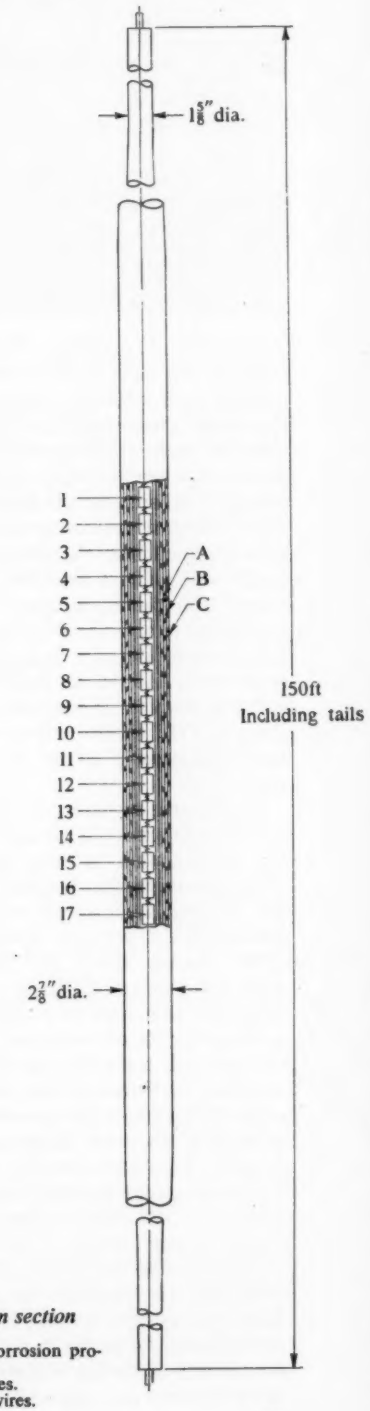
Submerged Repeaters

The development of the submerged repeaters followed distinctly different paths on each side of the Atlantic, the Americans concentrating on a flexible one-way unit and the British on a rigid two-way unit; Figs. 3 and 4 show the main features of these repeaters. After all considerations had been weighed it was decided to use the American repeaters on the main transatlantic crossing, although this meant laying two cables instead of one, and the British units for the Clarenville–Sydney-Mines section.

The American unit is a fascinating departure from all established practice, for it is but twice the diameter of the cable and with its long end-tapers forms no more than

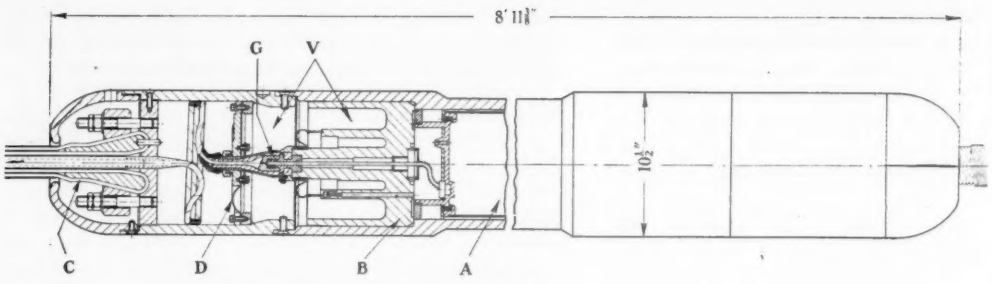
Repeater-unit sections.

1. Input terminal.
2. Input blocking capacitor.
3. Earthing capacitor.
4. Crystal.
5. Input network.
6. First-stage pentode.
7. First inter-stage network.
8. Second-stage pentode.
9. Second inter-stage network.
10. Third-stage pentode.
11. Output network.
12. Feedback network.
13. Feedback network.
14. Gas diode.
15. Drier.
16. Output blocking capacitor.
17. Output terminal.



3 *Repeater, Clarenville–Oban section*

A. Armour bedding and corrosion protection.
B. First layer of armour wires.
C. Second layer of armour wires.



4 *Repeater housing for Clarenville–Sydney-Mine Section*

A. Inner unit enclosing electrical apparatus.
B. Bulkhead (brazed in).
C. Armour clamp.
D. Flexible diaphragm enclosing Vistac, V.
G. Castellated gland.

a streamlined swelling. Within the bulge the components are housed in a series of articulated methylmethacrylate cylinders, and the whole unit is so flexible that it will pass round the 7ft-diameter cable drums and over the stern sheaves of a cable ship; thus it can be paid out while the ship is still in motion. Strangely enough, perhaps, the components of the repeater are far from the most modern available; indeed, most of them were designed more than 14 years ago, and the prototypes have been on test for most of this period. Here, of course, lies the explanation: the cost and difficulty of recovering part of the cable to repair a repeater or replace a faulty component is so great that the utmost reliability is essential, and the designers were faced from the outset with the problem of ensuring a trouble-free life of something like 20 years. Moreover, repeaters of this type have now been in service on the Havana–Key-West link since 1950.

The British repeater, on the other hand, is contained in a pressure-resisting housing some 9ft in overall length and of maximum diameter 10½in, designed to withstand pressures exceeding 3 tons/in^2. Sixteen of these units will be laid, at intervals of around 20 nautical miles, between Clarenville and Sydney Mines, where the depth never exceeds about 250 fathoms (0·3 ton/in^2). By using a housing of the above dimensions, the British Post Office has been able to produce a two-way repeater with facilities for the measurement of transmission levels from the terminal, and with sufficient duplication to enable the amplifier to function with acceptable distortion in the event of component failures which would prove disastrous in normal electronic equipment. Moreover, the use of modern high-performance valves with mutual conductances exceeding 6 000 micromhos facilitates the transmission of the wide frequency range envisaged for the Cabot Straits section, while the greater space permits components designed on more generous lines than can be fitted into the American housings. In common with the American design, however, the British repeater is no untried idea, for about 35 units of this and earlier designs are already in service in European waters, and more are being brought into use each year.

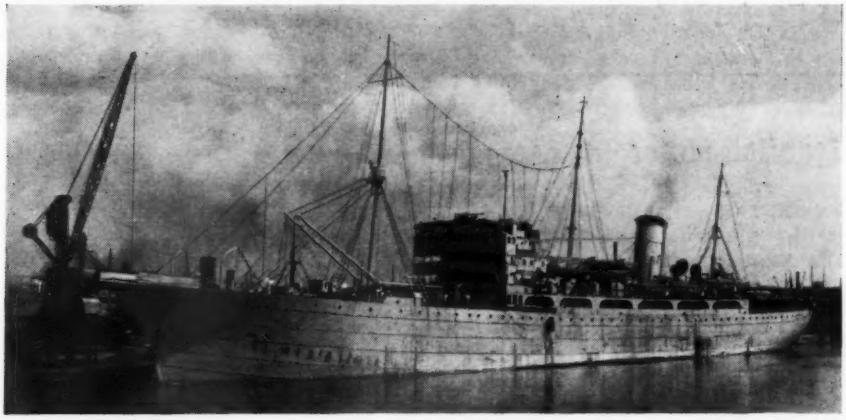
Laying the Cable

Thus the briefest outline of the two main items in the link; more details are, of course, given in the paper itself, where the authors also consider such additional problems as power feeding, testing and performance, and other matters in the province of the telecommunication specialist. For many engineers, however, the final item of interest is surely the cable ship itself—H.M.T.S. *Monarch*, the only cable ship in the world capable of carrying and laying the deep-water section of the Clarenville–Oban link in one operation. Named after the first vessel permanently fitted as a cable ship, the *Monarch* can carry between 5 000 and 6 000 tons of cable in her four tanks. She was launched in 1945, the largest cable ship in the world and the first to have electric cable engines. Fig. 5 shows the ship herself, and Fig. 6 shows schematically the method of paying out the cable from the tanks and over the stern sheaves.

The laying of the main length of cable is expected to take about 12 days, and the only period when there is a reasonable chance of settled weather on the route is between the middle of May and the beginning of September. However, since there will be something like ten miles of cable between the stern sheave and the ocean bed during the lay in the deepest parts of the ocean, the mechanical strains thrown on the cable during a moderate storm should not be so severe as to cause it to part. The first cable, from west to east, will be laid in 1955 and the return line in 1956, so that it will be nearly two years before the cable is opened for public service.

Some comment on the Scheme

When Sir Gordon Radley presented the paper on the cable before The Institution, the Lecture Theatre was filled to capacity, and the discussion which followed his lecture brought together a brilliant gathering of experts in the submarine-cable art. Dr. Buckley opened the discussion by a contribution which had been tape-recorded in America and flown across the Atlantic, and he was followed by Sir Stanley Angwin, reading the contribution which he had previously recorded and sent



5 *H.M.T.S. "Monarch"*

to America for the occasion (14th October, 1954) when the same paper had been presented before the American Institution of Electrical Engineers, at Chicago. Armed with great experience of international communication, these distinguished speakers amplified the background of the transatlantic project, its development, problems and utility, and looked into the future of transoceanic telephony.

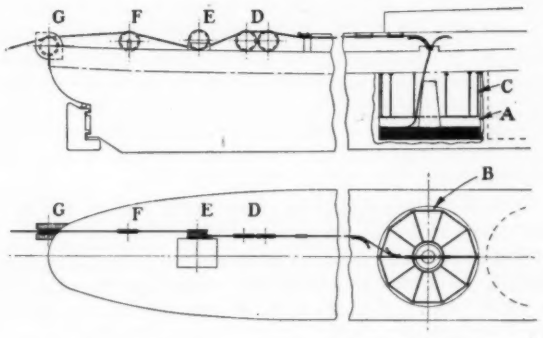
Sir Archibald Gill examined the finances of the scheme on the basis of a capital cost of £7 000 000 and an annual expenditure of £670 000, including interest, amortization, operating charges and the maintenance of a repair ship. Because of the differences in time between Europe and America, and the normal delays of long-distance interconnections, there would be only about 100 minutes of paid time each day; even so, on the basis of the present charge of £1 per minute, the scheme would pay for itself.

The problems of laying, and the design of cable ships and gear, attracted the attention of several speakers. Mr. A. C. Hartley, whose name will always be connected with Operation Pluto, told of several methods developed to overcome the difficulties of laying rigid repeaters. Sir Archibald Gill postulated a cable ship resembling an aircraft carrier, but there was no appeal in this idea to Captain Leech, long experienced in existing ships. He drew attention to the need for cable ships with all the facilities for the repair of deep-sea cables and repeaters, ships which could operate for long periods during the North Atlantic winter. Captain Leech also gave his views on kinking, which usually occurred when the ship was stationary with several miles of cable between it and the sea bed, and these met with the approval of Sir Gordon Radley.

Running throughout the discussion was the leitmotiv of component reliability as the determinant factor in the success or failure of the cable link, and Mr. Halsey collated these thoughts in the light of Post Office experience when he joined Sir Gordon in replying to the discussion.

The authors have offered a hostage to fortune in presenting the paper before the cable has been laid and operated, but the discussion of the paper has shown that the plans for the project are valid and that they should certainly lead to its successful completion.

It is a great venture, and its completion will be a worthy prize for those who have worked so long towards it.



6 *Cable-laying machinery on H.M.T.S. "Monarch"*

A. Cable tank (there are four).
B. Crinoline.
C. Crinoline block and tackle.
D. Jockey gear.
E. Paying-out drum.
F. Dynamometer.
G. Stern sheave.
All cable gear has a minimum radius of 3 ft 5 in.

But it is not the end, for the future is bright and full of exciting possibilities, as the development of new components and techniques already suggests that a cable link for transatlantic television is no idle dream, but yet another practical way of linking the Old World with the New.

DIGESTS *of papers in the proceedings*

Traction-Motor Maintenance

A DIGEST OF A PAPER (No. 1723) ENTITLED "THE OVERHAUL AND MAINTENANCE OF DIRECT-CURRENT TRACTION MOTORS," BY J. G. BRUCE, B.SC., MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN NOVEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

THE PERIOD of electric traction barely exceeds 50 years, and the efficient maintenance of traction motors has been developing over this period.

Maintenance of traction motors falls into three categories, namely running-shed maintenance, periodic overhaul and repairs. The patient endeavour of designers and maintenance engineers is to eliminate the third category altogether.

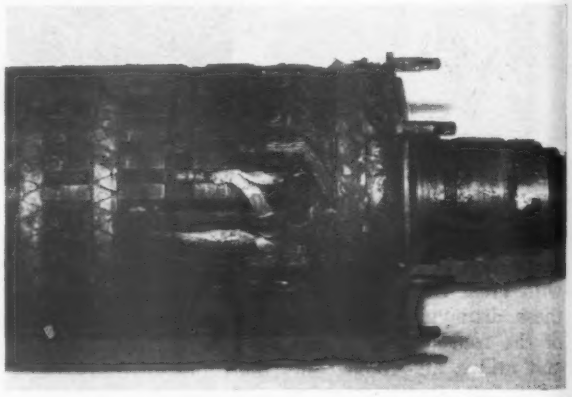
Running-shed maintenance consists mainly of inspection of brushgear and commutators and the greasing of bearings. Armature roller-bearings receive 1¼oz of grease every 12 months. The use of the fourth-rail system of power supply has encouraged the successful development of roller motor-suspension units to repeat the success of roller armature bearings. The life of roller bearings is difficult to predict with certainty, as is the reason for failure to reach a satisfactory life. Some roller bearings are still satisfactory after 20 years' life—equivalent to a million miles—while others of the same batch may fail to exceed an overhaul period of 200 000 miles.

Specialized apparatus has been developed by London Transport at Acton Works for dealing with the overhaul of traction motors on a continuous-flow basis. Cleaning stands, blowing-out enclosures, roller-bearing cleaning machines and coil presses are among the items designed for the purpose.

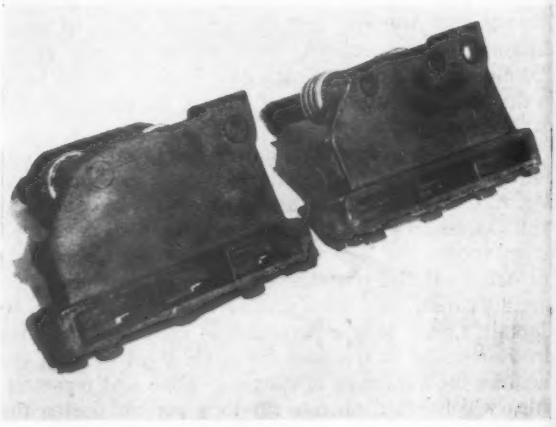
Overhaul periods of vehicles and traction motors now coincide. The motors are stripped, cleaned and repainted with insulating varnish. The commutators are turned with a high-speed tool, a cut of 0·01in being usually sufficient to clean up the ridging. The edges of the segments are bevelled and the mica is undercut. This undercutting should be at least 3/32in, in order to make the commutator capable of withstanding 300 000 miles service before the mica becomes "high."

Pinions are checked for fatigue flaws on a magnetic crack detector. In general, a gear wheel lasts twice as long as a pinion, owing to its lower rotational speed. The shorter life is not entirely due to extra wear, although some manufacturers make pinions of a slightly harder material than the gear wheel, so that the life of both will be approximately equal. London Transport does not now advocate the matching of gears and pinions, since motored wheels have to be changed frequently and the matching causes additional work and considerable wear.

Brushgear troubles arise from a lack of rigidity, which causes breakdown of the supports, and from wear in the boxes, which seems to be associated with current transfer.



1 *Defective traction-motor armature, which will require rewinding, arising from failure of the slot insulation of the armature bars*



2 *Two brush boxes before and after repair, showing the type of wear which is characteristic*

The improvement in design in traction motors has produced many machines which are able to last their lifetime without major repairs, but their most vulnerable part is still the armature. Special attention must there-

fore be devoted to armature repairs arising from failures. Certain types of armature, particularly long thin ones, seem to be prone to failure at the end remote from the commutator. This may be due to additional flexing of the armature, a result of its high length/width ratio, which produces relative movement between bar and slot. It is considered that the use of silicon-rubber type of insulation might help to overcome this, because of its resilient nature, without involving any of the high-temperature characteristics of this material. Experimental coils insulated with silicones are now in service. The improvements in temperature characteristics obtained by the use of these materials suggested that a totally-enclosed motor without fans might become a possibility, even with a restricted size.

The standard practice in insulating armature bars is to provide as much bar-to-slot insulation as possible. The voltage between bars on a 600-volt machine is small, but the voltage to earth can rise excessively. After the placing of the bars in the armature slots, a preliminary h.v. test not exceeding 2 500 volts a.c. is applied before the core bands are fitted. Core bands are still preferred for normal-duty traction motors, since it is felt that a more solid result is obtained. The banding should be removed and renewed if any doubt exists as to its soundness. The h.v. test is repeated after the final coat of insulating paint has been applied, and a bar-to-bar test is made to ensure good continuity.

Main and interpole coils sometimes require replacement, and these are wound with flat copper strip insulated between turns and layers on a start-and-stop slow-operation winder specially developed for the purpose. The new silicone-glass insulation can be used for field coils also.

Artificial Dielectrics

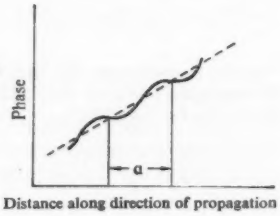
DIGESTS OF FOUR RADIO SECTION PAPERS ON ARTIFICIAL DIELECTRICS. THE FULL PAPERS ARE PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

"The Properties of Artificial Dielectrics at Centimetre Wavelengths" (Paper No. 1699), by J. Brown, M.A., Associate Member, and Willis Jackson, D.Sc., D.Phil., F.R.S., Member.

THE SO-CALLED artificial dielectrics comprising regular arrays of conducting elements are of importance at centimetric wavelengths, since they provide a light and cheap material for the construction of lens aerials. A major difference between artificial and normal solid dielectrics is that the former do not necessarily have the same permeability as free space and are, in general, diamagnetic, i.e. the relative permeability is less than unity. The similarity in all other respects has led to the application to artificial dielectrics of results derived from a study of solid dielectrics, without this being in all cases justifiable. The first of the two papers by Mr. Brown and Dr. Willis Jackson seeks to provide proofs of certain of these results.

The basic parameters of a medium at centimetre wavelengths are its refractive index and its wave impedance. The former may be defined for solid materials as the ratio of the phase velocity of a plane wave in free space to that of a wave in the medium. A slight difficulty arises in extending this definition to artificial dielectrics because of the way in which the phase varies along the direction of propagation (Fig. 1). The definition may

1 *Variation of phase in artificial and solid dielectrics*
——— Artificial.
— — — Solid.



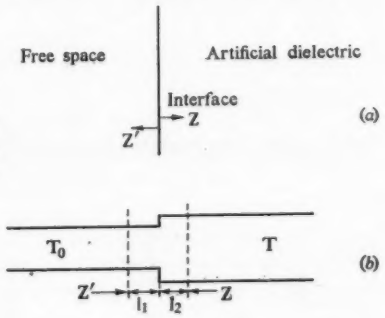
be used if the phase velocity in the artificial dielectric is taken as an average value over the lattice spacing a. The refractive index of a solid material is given by

$$n = (\epsilon_r \mu_r)^{\frac{1}{2}}$$

in which ϵ_r and μ_r are respectively the relative permittivity and permeability. A formal proof that this equation also applies to artificial dielectrics is given.

The wave impedance of a solid material is usually defined as the ratio between the electric and magnetic field strengths at a point within the material when a plane wave is being propagated. The principal use of the wave

2 *Free-space/artificial-dielectric combination and its representation as a transmission-line circuit*



impedance is in the calculation of the reflection coefficient at an interface between two different media. The original definition cannot be used for most artificial dielectrics, and it is therefore suggested that the wave impedance should be defined to give the correct value of the reflection coefficient at the interface between free space and the artificial dielectric. A complication which arises for artificial dielectrics is an effective phase shift in both the reflected and transmitted waves at the interface. The free-space/artificial-dielectric combination shown in

Fig. 2(*a*) may thus be represented by the transmission-line circuit shown in Fig. 2(*b*). The phase shifts determine the values of the additional lengths of line, l_1 and l_2, and they arise because of the excitation of evanescent fields near the interface.

The paper forms an introduction to the succeeding papers by Dr. El-Kharadly and Dr. Primich in which various phenomena associated with artificial dielectrics are investigated experimentally.

"Some Experiments on Artificial Dielectrics at Centimetric Wavelengths" (Paper No. 1700), by M. M. Z. El-Kharadly, B.Sc., Ph.D., Graduate.

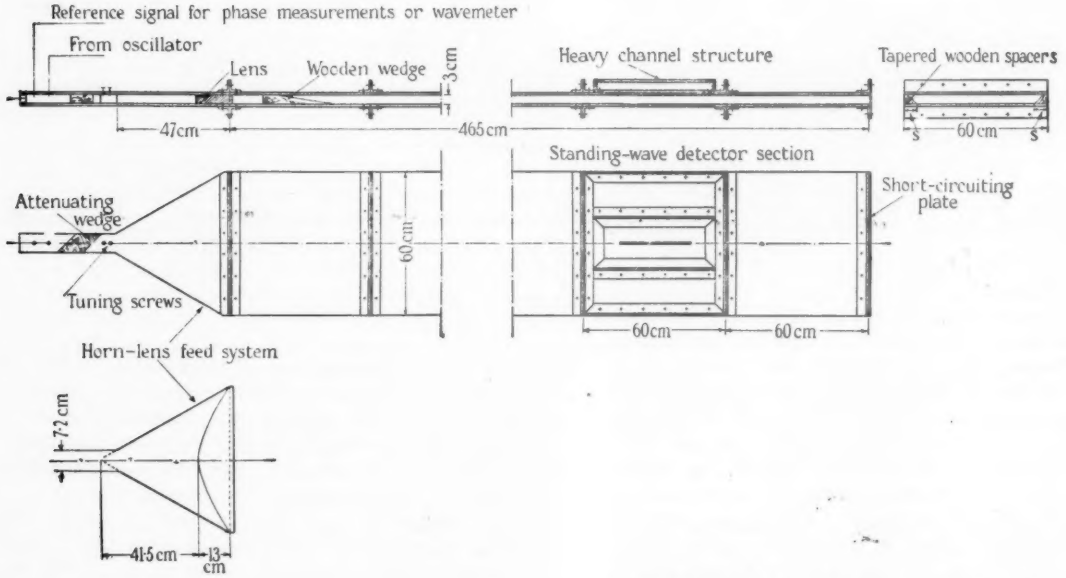
SINCE THE PRINCIPAL USE of artificial dielectrics is the construction of microwave lens aerials, a convenient method for measuring their properties at centimetric wavelengths is desirable. Solid dielectrics are usually examined by enclosing them in a waveguide or cavity resonator, but this cannot be done for artificial dielectrics unless the spacings between elements are much less than the waveguide or resonator dimensions. A parallel-plate transmission line shown in Fig. 3 has been developed to overcome this difficulty. The design of the line is such that the field within the plates approximates to that of a free-space plane wave. Artificial-dielectric samples may be placed between the plates and measurements carried out by the same methods as are used with waveguides.

The author has investigated experimentally a number of artificial dielectrics, using the plate transmission line. The phase shifts which occur at the interface between free space and the artificial dielectric have been observed to affect the measurements, and a method by which these phase shifts may be determined approximately has been devised and shown to give consistent results.

Dr. El-Kharadly has given particular attention to the occurrence of dispersion in artificial dielectrics, and he discusses in the paper the ways in which it may arise. A rapid change of the refractive index with frequency may take place, either if the conductors of the artificial dielectric are resonant or if the spacings between the elements approach half the wavelength of operation. Examples of both types of dispersion are studied in the paper, and the experimental results are shown to be in qualitative agreement with theoretical expectations.

"A General Experimental Method to determine the Properties of Artificial Media at Centimetric Wavelengths, applied to an Array of Parallel Metallic Plates" (Paper No. 1701), by R. I. Primich, B.Sc., Ph.D., Graduate.

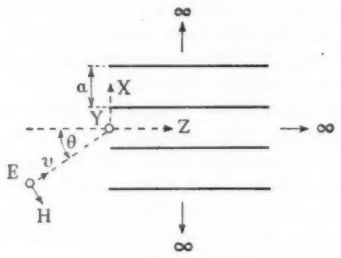
THE ARTIFICIAL MEDIUM studied in the paper by Dr. Primich is shown in Fig. 4, and consists of a semi-infinite system of perfectly-conducting thin parallel plates. The properties of the medium are completely specified by the refractive index and by the reflection and transmission coefficients at the interface. These coefficients are complex, because of the phase shifts in the reflected and transmitted waves caused by the evanescent fields established in the vicinity of the interface. Dr. Primich describes an experimental method by which the reflection and transmission coefficients can be determined experimentally. The parallel-plate medium was selected as a convenient one with which to illustrate the method, since exact values for the coefficients have been obtained theoretically.



3 *Construction of parallel-plate transmission line*

The measurements have been carried out with the transmission line described in the paper by Dr. El-Kharadly. Since a semi-infinite stack of plates could not be used, a method was devised whereby the required information could be extracted from measurements on stacks of finite length. The technique used is a modification of that developed by Weissfloch for waveguide measurements and involves positioning the stack at a varying distance in front of a short-circuit. The distance of a field minimum from the stack is then plotted against the distance from the stack to the short-circuit and the reflection coefficient of the stack is determined from the resulting curve. This is repeated for stacks of different lengths, and the reflection and transmission coefficients for a single interface are deduced from the variation of the stack reflection coefficient with the length of the stack.

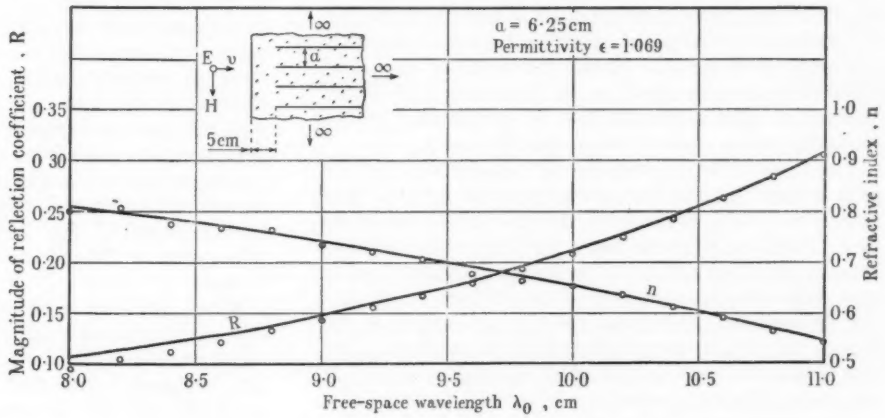
Experimental results are plotted in Figs. 5 and 6, together with the corresponding theoretical curves. The magnitude of the reflection coefficient agrees to within 5%, and its phase to within 5°, over most of the wavelength range investigated. The sources of these errors are the finite width of the transmission line, the departures of the field within the line from the desired plane wave, and the expanded dielectric used to support the plates of the stack.



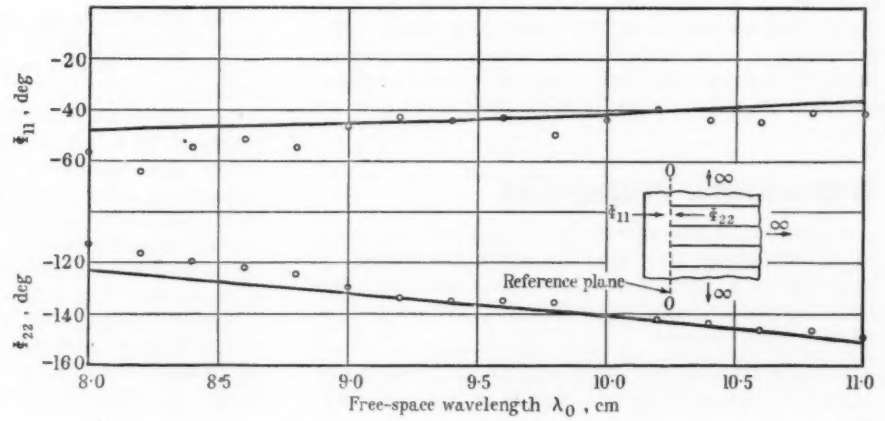
4 *Parallel-plate medium*

"The Relative Permittivity of Tetragonal Arrays of Perfectly Conducting Thin Discs" (Paper No. 1702), by J. Brown, M.A., Associate Member, and Willis Jackson, D.Sc., D.Phil., F.R.S., Member.

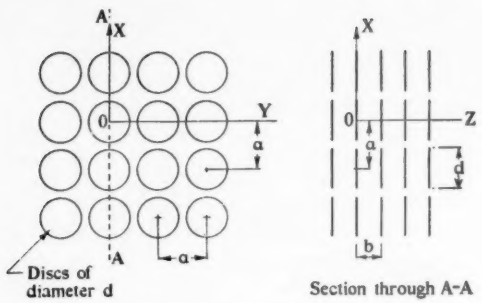
REASONABLY ACCURATE PREDICTIONS of relative permittivity may be made for many types of artificial dielectric, i.e. arrays of conductors which behave similarly to solid dielectrics. An exception is the tetragonal array of conducting discs shown in Fig. 7, for which previous theoretical results are inaccurate except for a



5 *Refractive index and magnitude of reflection coefficient for a single interface*



6 *Phase of reflection coefficient for a single interface*



7 *Tetragonal array of discs*

very limited range of disc diameters and spacings. These results have been obtained from the Lorentz theory, which is used in studies of non-polar solid dielectrics, and are satisfactory for cubic arrays, in which the spacings a and b are equal. The Lorentz theory cannot easily be extended to tetragonal arrays, in which a and b are not equal.

Another method for the analysis of artificial dielectrics has been developed from the similarity between plane waves in free space and waves on a transmission line, and leads to an equivalent circuit for propagation within the artificial dielectric. These two methods are combined in the second paper by Mr. Brown and Dr. Willis Jackson to give a formula for the permittivity of the tetragonal array which is valid when b exceeds $0{\cdot}6a$.

The Lorentz theory rests on the assumption that the field caused by the charge distribution on any disc corresponds to an electrostatic dipole at the centre of the disc. For closely spaced discs, e.g. when b is much less than a, this assumption is no longer justifiable and a more accurate representation of the field set up by each disc is required. An exact solution is unlikely to be found, because of the complexity of the problem. The modification to the field caused by the close proximity of successive discs may be partially calculated, however, and a formula for the relative permittivity of the array has been derived for circumstances in which b is less than $0{\cdot}6a$. A comparison of the theoretical values with previously observed experimental values of the relative permittivity shows that each of the formulae is accurate to within 2% over its range of applicability.

Tropospheric Propagation

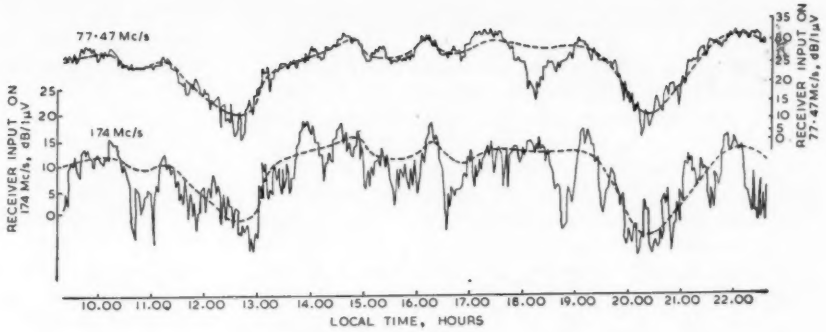
A DIGEST OF A RADIO SECTION PAPER (No. 1747) ENTITLED "SOME FEATURES OF V.H.F. TROPOSPHERIC PROPAGATION," BY M. W. GOUGH, M.A., ASSOCIATE MEMBER. THE FULL PAPER IS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

THE PAPER discusses an analysis of about 15 000 hours of continuous signal-strength records of controlled low-power c.w. transmissions (mostly on about 170 Mc/s) made in tropical and Mediterranean regions. More than 100 diverse radio paths averaging about 40 miles in length have been continuously recorded for about 6 days each, yielding statistical material valuable in v.h.f. communication planning and evidence of tropospheric conditions which can profoundly influence v.h.f. propagation.

The analysis of signal-strength records in the light of propagation theories applicable to idealized tropospheric conditions has permitted in simple cases the deduction, in terms of meteorological variables, of tropospheric structures existing during the tests. This assists in forecasting the behaviour of untested radio paths subject to similar climatic conditions. A common condition comprises an atmospheric stratum near the ground, having a small negative gradient of refractive index and being surmounted by a horizontally stratified layer within which the refractive index decreases much more rapidly. When the radio terminals lie below this elevated discontinuity, signal-strength variations can be interpreted in terms of interference between a signal propagated near the ground and a signal reflected from the layer above. The latter produces randomly recurrent fades which are superimposed on the relatively slow signal-strength changes governed by variations in the refractive-index gradient of the surface stratum. Thus, if recorded rapid fades are smoothed out, as in Fig. 1, we are left with a signal trend reflecting only the variations in refractive-index gradient near the ground. Recording on two simultaneously transmitted frequencies greatly simplifies the separation of layer-reflection influences from those of surface refraction. It can be shown that, under suitable conditions of test, the smoothed simultaneous records should be well correlated, as exemplified in Fig. 1, which is a section of record taken over a 200-mile water path between Israel and Cyprus.

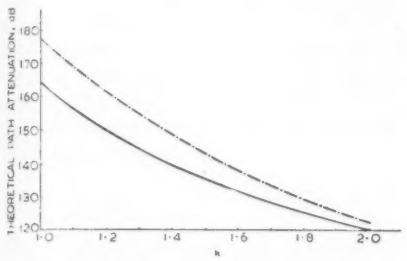
When the test path permits computation of the theoretical received signal strength in terms of the surface refractive-index gradient (disregarding elevated layers in this instance), smoothed values of recorded signal-strengths can be associated with specific values of refractive-index gradient. Thus an estimate can be made of the variations in the latter occurring during the test. Such statistics assist the prediction of the performance of other v.h.f. routes subject to similar meteorological conditions.

The degree of atmospheric refraction is usually best expressed in terms of the effective-earth-radius factor rather than the related refractive-index gradient. For engineering utility, therefore, Fig. 2 shows the theoretical variation of the path attenuation (between half-wave dipoles) with the effective-earth-radius factor k, for two frequencies simultaneously transmitted over the Israel–Cyprus path. Fig. 3 shows the cumulative distributions of path attenuation on 77·47 Mc/s measured over this route during summer (May–August) and autumn (September–November). Fig. 4 shows the result of combining Figs. 3 and 2 to derive cumulative dis-



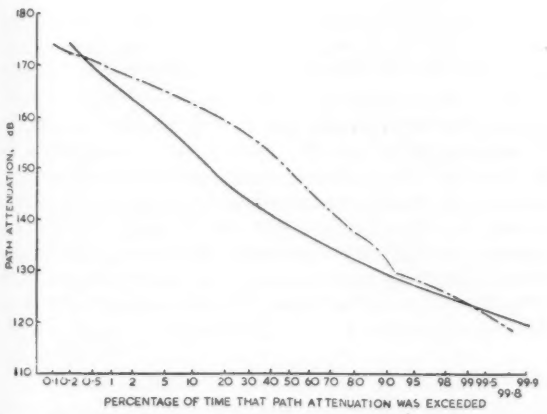
1 *Correlated simultaneous signal records*

— — — — Smoothed curves.



2 *Israel–Cyprus path: theoretical variation of path attenuation with* k *for the two test frequencies*

——— 77·47 Mc/s. —·— 174 Mc/s.



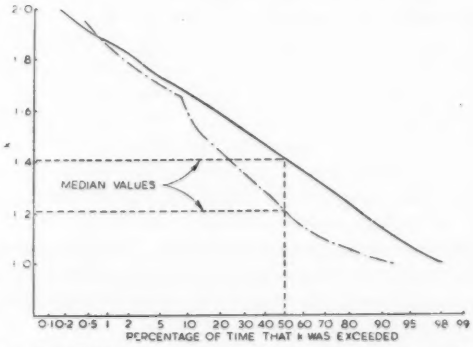
3 *Israel–Cyprus path: cumulative distributions of path attenuation*

77·47 Mc/s during summer and autumn.
——— Summer. —·— Autumn.

tributions of effective-earth-radius factor for the two seasons.

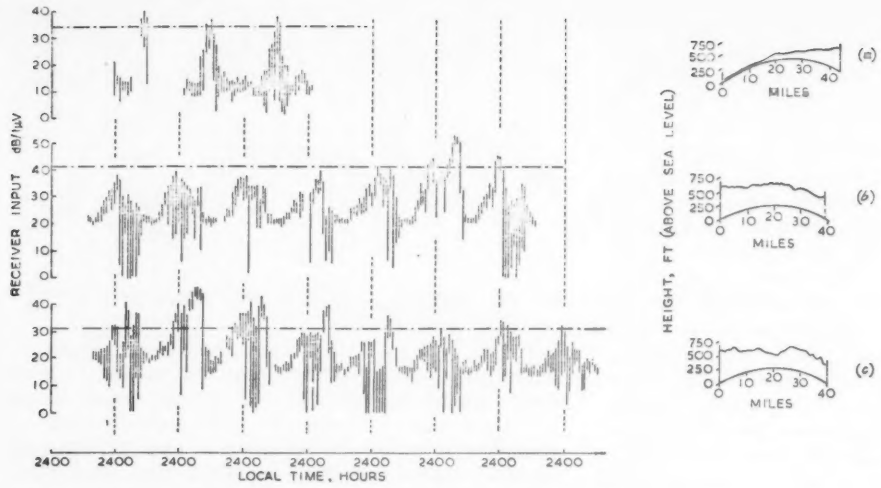
The hourly signal range charts shown in Fig. 5, derived from continuous recordings made over land paths in West Africa, indicate a further important tropospheric state, namely the nightly development of surface ducts presumed to extend from the ground to some height above the terminals. The pronounced diurnal variations imply a period of approximately "standard" refraction ($k = 4/3$) during much of the day, changing nightly to a period of intense super-refraction ceasing very abruptly at about 0900 hours next day. Nocturnal signal-strengths occasionally exceeded the free-space value by 6dB, which, adopting a simple "2-ray" explanation that disregards the discontinuity at the top of the layer, implies constructive interference between a direct and a ground-reflected wave. For the paths under consideration (Fig. 5) this condition requires an effectively concave earth, implying a negative value of k and the existence of a surface duct. The Table gives the calculated values of effective earth radius factor k, modified refractive-index gradient dM/dh, and refractive-index gradient dn/dh.

Path	Distance	Aerial heights above ground	Test frequency	k	dM/dh	dn/dh
	miles	ft	Mc/s		*M*-units/m	per metre $\times 10^{-6}$
(*a*)	44	150 80	174	−0·21	−0·74	−0·9
(*b*)	39	80 80	180	−0·16	−0·96	−1·1
(*c*)	38	80 80 80	180	−0·155	−1·0	−1·2



4 *Israel–Cyprus path: cumulative distributions of* k

Summer and autumn, based on the 77·47-Mc/s test.
——— Summer. —·— Autumn.

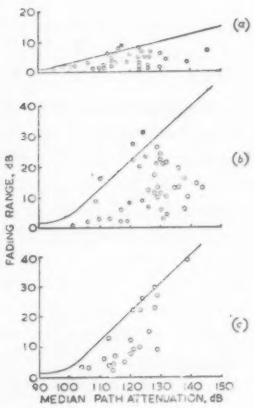


5 *West African land paths: hourly signal range charts and profiles*

(*a*) Lagos–Ipara (Nigeria), 174 Mc/s.
(*b*) Abuo–Prang (Gold Coast), 180 Mc/s.
(*c*) Salaga–Prang (Gold Coast), 180 Mc/s.
—·— Free-space signals.

gradient *dn/dh*, necessary for the observed state of constructive interference.

The above nocturnal values, which may sometimes have been exceeded slightly, are compatible with available world-wide data on tropospheric layers. These data imply a probable limit of about 200 ft on the height of the surface layers. Although they qualify as ducts, it is calculated that the layers cannot produce trapping on frequencies below about 350 Mc/s.



6 *Mass plots of fading range versus median path-attenuation*

(*a*) Land paths in Malaya, Ceylon and E. Africa.
(*b*) Land paths in Nigeria and Gold Coast.
(*c*) Water paths in Malaya, Gold Coast, E. Africa and Mediterranean.

Three distinct types of diurnal signal-strength variations have been noted; these are respectively characteristic of land paths in Malaya and Ceylon, land paths in West Africa, and coastal paths in West Africa. Tropical and Mediterranean water paths sited well away from coastlines showed no diurnal variations, but exhibited random fading.

An analysis of about 100 signal-strength records from tropical and Mediterranean regions, using frequencies of about 170 and 80 Mc/s, has revealed, under broadly similar meteorological conditions, an approximate statistical connection in this band between the median path-attenuation and the fading range measured in a specified way. Mass plots of this relationship, relevant to specified geographical conditions, are shown in Fig. 6. The lines on the charts serve to estimate conservative fading allowances when v.h.f. communications are being planned under the conditions specified and where the median path-attenuation can be approximately calculated.

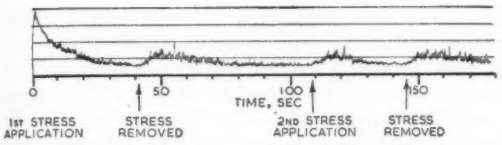
Noise in Barium Titanate Crystals

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1752) ENTITLED "NOISE GENERATION IN CRYSTALS AND IN CERAMIC FORMS OF BARIUM TITANATE WHEN SUBJECTED TO ELECTRIC STRESS," BY A. C. KIBBLEWHITE, M.SC., PH.D. THE FULL PAPER IS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

ONE OF THE EXPERIMENTS designed to test the validity of the original Weiss domain theory of ferromagnetic behaviour was the detection of the noise now known as the Barkhausen effect. The establishment of the existence of a domain structure in the barium-titanate group of

dielectric materials suggested that an analogue to this effect should exist in these materials, and experiments were carried out to test this assumption. The phenomenon is not readily established because of the variety of alternative noise sources to be found in dielectrics, but ambiguity was largely removed by a careful selection of test specimens. Experiments were carried out on both single crystals and ceramic capacitors of barium titanate, the most interesting results being obtained from the former.

Considerable noise was observed when a specimen crystal was subjected to electric stress. Maximum noise activity occurred at stresses below 5kV/cm, becoming negligible as saturation stress was reached. When the stress was reduced to zero, noise again appeared, the pulses constituting this noise being dominantly of reverse polarity compared with those produced when the stress was applied. If after the removal of stress the same maximum stress was reapplied in the same direction, the noise output was much smaller than on the first application (Fig. 1).



1 *Noise response to the application and removal of a stress of 2·5 kV/cm*

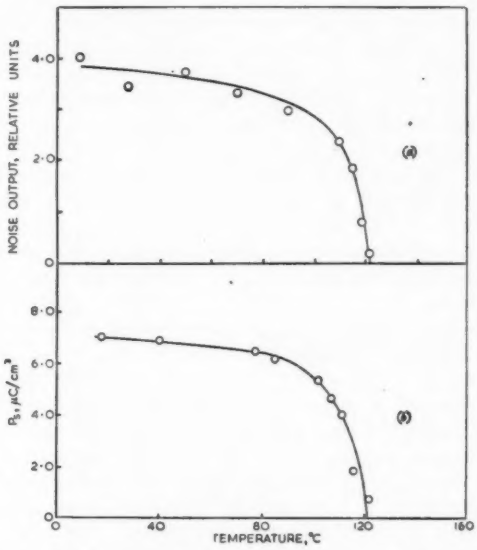
Each of these properties identifies the noise as being of Barkhausen origin. Thus, because of saturation of the polarization, the maximum noise activity may be expected to occur at a stress lower than 5kV/cm; because the domain vectors are again orientated at random when the stress is removed, some noise should appear on the discharge of the specimen, while the dependence of the charging noise on the previous electrical history of the specimen is identifiable with the phenomenon of remanence.

A necessary condition that the noise observed is really Barkhausen in origin, however, is that it must disappear above the Curie point exhibited by barium titanate at 120°C. Fig. 2(*a*) shows that the noise produced by an applied stress does, in fact, fall to zero at around 120°C, the temperature at which the domain structure of barium titanate disappears. Furthermore, since the Barkhausen noise is associated with "irreversible" incremental changes in polarization, it should be intimately related to the spontaneous polarization. The observed relationship between the spontaneous moment, P_s (calculated from 50c/s hysteresis loops), and the noise response is shown in Fig. 2(*b*).

From a knowledge of the size of the individual noise pulses it was possible to calculate a volume within which the polarization changes discontinuously. In the crystal concerned this was found to be 5×10^{-8}cm^3.

The fact that Barkhausen pulses were observed for several seconds after the application of a d.c. field suggested that the polarization produced by a given field is a function, not only of its magnitude, but also of the time it is applied to the specimen. Similar small time drifts in the incremental permittivity provided additional confirmation.

Excessive noise in ceramic specimens of barium titanate was readily identified with sources not truly



2 *Noise response and spontaneous polarization plotted against temperature*

characteristic of the material. However, in carefully prepared specimens the noise output under applied stresses below 10kV/cm was shown to be Barkhausen in origin. Above 14kV/cm, however, additional noise pulses occurred in even the best ceramic specimens obtainable. It is possible that this noise was associated with the semi-conduction properties of the material.

Under a.c. excitation the results were similar, with the exception that at about 15kV/cm additional very large noise pulses appeared. In all probability these were the result of internal discharges across microvoids within the bulk of the ceramic.

CORRESPONDENCE

LETTERS TO THE JOURNAL ON ELECTRICAL ENGINEERING SCIENCE OR TECHNOLOGY ARE WELCOME. IN PARTICULAR, MEMBERS (AND OTHER AUTHORS) WHO ARE SUBMITTING A PAPER TO THE INSTITUTION ARE ASKED TO CONSIDER THE POSSIBILITY OF MAKING A BRIEF PRELIMINARY ANNOUNCEMENT BY MEANS OF A LETTER BEFORE THE PAPER IS WRITTEN. CORRESPONDENCE SHOULD BE ADDRESSED TO THE SECRETARY OF THE INSTITUTION AND MARKED "FOR PUBLICATION." CARBON COPIES OF THE LETTERS SHOULD BE INCLUDED.

The Leader Strokes of the Lightning and Spark Discharges

From C. E. R. BRUCE, M.A., D.Sc., *Member*

In a recent paper[1] Schonland has put forward a theory to account for the stepped nature of the first leader stroke of a lightning discharge. This theory is an alternative to mine,[2] which he rejects for a reason that seems to me inadequate. While he agrees that the leader is a thermally ionized channel, carrying a current of a few hundred amperes, and is at a potential of 10^7–10^8 volts relative to the surrounding space,[2] he appears to envisage the total current as flowing along the whole length of the leader to its tip, simply as a charging current. The channel thereafter remains charged without losses for a period of the order of 10^{-2}sec until the passage in the reverse direction of the return stroke. However, there would appear to be no justification for envisaging a current of 300amp at the tip of the leader, since the change from a corona to an arc-like discharge has been observed to occur in the laboratory spark discharge at a current of the order of 1amp,[4] in accordance with my original suggestion.[3] Again, I think that such a column would be subject to high lateral losses of charge by corona discharge.[3] If we neglect these and adopt Schonland's view, it is difficult to understand why the charge which flows to earth during the return stroke proper—i.e. during approximately the first 100microsec, after which time the return stroke has reached the cloud charge—is not at least equal to that lowered during the leader stroke. On the contrary, this charge flowing during the return stroke proper is in fact about one-tenth of the leader stroke charge.[5] My explanation of this difference is that the remainder has been diffused laterally from the channel by corona discharge, and can find its way back to the channel, and thus to earth, only gradually, by a corona mechanism of reverse polarity when the potential of the channel with respect to the surrounding space is reversed. It is these reverse corona currents which seem to me to account for the "c" field change,[6] and for the associated currents of long duration—of the order of 1 000amp or more for several milliseconds—which may continue to flow after the return stroke proper, and which have not hitherto been satisfactorily explained.

Again, Schonland obtains for the current density in the thermally ionized channel a value of the order of 10^{-3}amp/cm^2. However, the values observed in thermally ionized columns, carrying even small currents of the order of 1amp or less during laboratory discharges in air at atmospheric pressure, are always greater than this value by a factor of 10^3 or 10^4. As the current density in the return stroke will be of the order of 10^3amp/cm^2, Schonland's figure implies that leader and return stroke differ in this respect by a factor of 10^6, and it is doubtful if this is compatible with the photographic evidence. Furthermore, the temperature of such a channel as Schonland visualizes would have to be about 3 000°C. With a current of 300amp and a voltage gradient of even 10^3 volts/cm, the time required to supply the energy to produce such a column would be of the order of 0·1–1sec, whereas Schonland appears to visualize this condition as being set up in a time of 10–100microsec.

The reason he gives for rejecting what I should now call the corona/arc transition theory of the stepped structure,[2] i.e. the transition from a field-maintained to a thermally-ionized arc core, is that it would lead one to expect the step to cause a large, sudden change in the electric, as well as in the radiation, field. However, for a leader, say, 1km in length at an average potential of 10^7 volts, I regard the charge required to maintain the lateral corona currents from the channel during the apparent pause of 50microsec prior to a step as being of the order of 3×10^{-2} coulomb.[2] On the other hand, the charge required to effect the sudden change of the potential gradient in the last 10m of the channel from, say, 5 000 volts/cm to 50 volts/cm is only of the order of 10^{-4} coulomb, with the capacitance of the channel taken as about 0·1 $\mu\mu$F/cm. It is thus to be expected, on my theory of the steps, that the change in the electric field due to the step will be less than one-tenth of that occurring during the pause, as is actually observed.[1]

(1) SCHONLAND, B. J. F.: *Proceedings of the Royal Society*, A, 1953, **220**, p. 25.
(2) BRUCE, C. E. R.: *ibid.*, 1944, **183**, p. 228.
(3) BRUCE, C. E. R.: *Nature*, 1941, **147**, p. 805.
(4) KOMELKOV, V. S.: *Doklady Akademii Nauk S.S.S.R.*, 1947, **68**, p. 57.
(5) BRUCE, C. E. R., and GOLDE, R. H.: *Journal I.E.E.*, 1941, **88**, Part II, p. 487.
(6) APPLETON, E. V., and CHAPMAN, F. W.: *Proceedings of the Royal Society*, A, 1937, **158**, p. 1.

LONDON

ORDINARY MEETINGS

The opening meeting of the session was held on the 7th October, 1954, when the President delivered his Inaugural Address. An account of this meeting appears on page 5.

At the second Ordinary Meeting, on the 4th November, 1954, Sir Gordon Radley and Mr. R. J. Halsey presented the paper entitled *A Transatlantic Telephone Cable*, written by themselves and their two American co-authors, Dr. M. J. Kelly and Mr. G. W. Gilman. This meeting was one of the most successful held in recent years, and there was an attendance of nearly 600 members. The interest in the paper has no doubt been increased by the fact that it has been written and presented while the project it describes is still in progress. An article on the telephone cable will be found on page 25.

For the third Ordinary Meeting of the session, on the 2nd December, 1954, the paper by Mr. J. A. Broughall and Mr. K. J. Cook on *The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways* was selected. This paper is full of interest for many electrical engineers who are not traction specialists, and its presentation and the ensuing discussion were keenly followed by an appreciative body of members. Two short films illustrating the track, locomotives, overhead equipment, Penistone control room, etc., were shown at the meeting. An account of the electrification based on Mr. Broughall and Mr. Cook's paper will appear in a subsequent number of the *Journal*.

EXTRA MEETING

On Thursday, 11th November, 1954, Mr. J. G. Bruce presented a paper entitled *The Overhaul and Maintenance of D.C. Traction Motors* before a well-attended Extra Meeting to which members of The Institution of Locomotive Engineers had been invited. Mr. S. E. Goodall was in the chair; in welcoming the visitors he referred also to the presence of the Honorary Secretaries of Students' Sections, who were attending their Annual Conference in the Institution building.

The paper reviews the maintenance practices developed by London Transport for axle-hung traction motors and described the equipment used for this purpose at the Acton works. The author gave an interesting, brief lecture emphasizing many points in the paper with some additional ones that he illustrated by 16 lantern slides. A digest of the paper appears on page 30.

Mr. A. W. Manser, Chief Mechanical Engineer (Railways) of London Transport, who opened the discussion, stressed the arduous duties which London Transport's traction motors have to perform. He illustrated this by revealing that the control and brake equipments on each London Transport train operated some 900 and 2 500 times a day respectively, a most severe condition which he thought would not be found elsewhere in the United Kingdom.

Fourteen speakers took part in the discussion, which covered a very wide ground, ranging from references to the early history of traction motor performance on the London surface and Tube lines to many design details of these motors, their suspension and gearing, and the special tools and equipment required for their maintenance. As an illustration of the different service conditions which British traction motors have to meet, Mr. Sykes wittily pointed out that it seemed that, while London Transport were leaning towards a totally enclosed motor, the Southern Region of British Railways were striving to open out their motors and thereby increase their ventilation.

The discussion took a lively turn when Mr. Wortley disagreed with the author's remarks that Cardan-shaft drives were more applicable to lighter vehicles, and he mentioned that these drives had been successfully used on the Toronto Subway cars. Mr. Manser, however, intervened to point out that all axles of the Toronto cars were motored and these motors were small; the author had said that the Cardan-shaft drive was suitable for small motors. Mr. Manser added that, while the drives on the Toronto cars had enabled the traction motors to be bogie-mounted and therefore entirely spring borne, much of the unsprung weight saved by doing this had been put back on the axles in the form of the gear unit.

Mr. Hamilton, of the New Zealand Government Railways, who was on a visit to Great Britain, gave the meeting some interesting facts about the suburban and main-line electric services in his country.

Other speakers raised questions relating to: brush pressures and wear; the design of brush holders; and the use of silicones, particularly their application to totally enclosed motors and the effect of this on commutator wear. The method of fitting and removal of pinions was discussed, as well as the important subject of roller bearings, particularly their use by London Transport for axle-hung motor suspension. Before the author replied, Mr. Hopkins paid tribute to the help which London Transport always gave to other railways both at home and abroad as well as to the manufacturers.

Mr. Bruce in his reply dealt admirably with all the questions raised. Perhaps not the least interesting of the points which emerged from the discussion and his closing remarks was the fact that the ventilation holes were omitted from the armature cores of London

Transport motors. It is hoped that Mr. Bruce in his written reply to the discussion on his paper may care to comment on the effect that this has on a motor's temperature rating or, alternatively, on its size and weight.

H. H. C. B.

MEASUREMENTS SECTION

Chairman's Address

In all Sections of The Institution the first meetings of the session are marked by a feeling of anticipation, not only for the programme itself, but also for the subject and content of the new Chairman's Address, which is usually closely linked to his day-to-day interests and experience. It was to be expected that Mr. M. Whitehead, the Chairman of the Measurements Section, would deal with that fundamental measuring device, the electricity meter, at the first meeting of the session on the 19th October, 1954; for the electricity meter has so often been the subject of papers and discussion since the inception of the Measurements Section. The meeting was honoured by the presence of the President.

In his opening remarks Mr. Whitehead referred to the effects of specialization, pointing out that this need not lead to narrowness of view—rather the contrary. "It is the end product that is narrow, whilst the experience is wide." His argument was convincingly demonstrated as his Address developed, for not only did he analyse several fundamental characteristics of the induction disc and theories regarding its operation, but he also proceeded to show how the performance of an integrating meter can be related to the cost of metering electrical power. In support of his argument he showed a number of curves that indicated the economic limits to which technical performance can be improved under various operating conditions. A short summary of the Address appears on page 22.

The ceremony of Mr. Whitehead taking over his official position from the retiring Chairman was marked by two happy speeches by Dr. Denis Taylor and Mr. H. S. Petch, who in reviewing the past session, emphasized the work and care that had marked the year of office of Mr. J. F. Coales. Despite an eloquent disclaimer by Mr. Coales which might have led his hearers to believe he had little to do with the success of the past session, no one was in any doubt about the value which members set upon the work he had performed so consistently and cheerfully.

W. B.

Annual Dinner

The Annual Dinner of the Measurements Section was held at the Café Royal on the 9th November, 1954, when the company present numbered 276.

Mr. M. Whitehead, the Chairman of the Section, presided, and in welcoming the guests referred to the ever-widening scope of the Section. The opinion had been expressed that Specialized Sections were unnecessary, but the activities of The Institution were now so extensive that it was doubtful if its work could be effectively handled without the Sections. Members of individual Sections should avoid the tendency to acquire a jargon quite unintelligible to the members of the other Sections, and they should never lose sight of the essential unity of the members of The Institution. These were one or two of the many matters which the President, who had honoured them with his presence that evening, was watching. Everyone hoped that Mr. Eccles would have a pleasant year of office, and they were sure that he would successfully accomplish the heavy task he had undertaken.

The President, who expressed his pleasure at being present, regarded sectionalization as analogous to the human body with its five senses separate and distinct, each of which performs its function to the benefit of the body corporate; when one sense cannot operate properly the whole body is at an immediate disadvantage. The Specialized Sections performed their functions within the body of The Institution, and this was essential for maintaining The Institution as a vital and healthy organization.

Mr. W. Bamford, Vice-Chairman of the Section, in proposing the toast of the Chairman, observed that the Measurements Section either by luck or good management were able to arrange their Annual Dinner at the beginning of the session, and this gave an early introduction of the Chairman to a very large number of members at one time. All would wish Mr. Whitehead well in the coming months, and he could be assured of their support during his period in the chair.

A short entertainment was provided by Mr. Gordon Turner.

RADIO SECTION

Chairman's Address

At the first meeting of the session the new Chairman, Mr. C. W. Oatley, delivered his Address on *New Materials and the Electrical Engineer*. He referred to the great progress which had been made in the past two or three decades in the production of new materials for electrical engineers, and for radio engineers in particular. Special reference was made to the property that appreciable electrical conduction could, in suitable circumstances, take place in non-metallic solids; the theory of this process was now in a relatively satisfactory state. Mr. Oatley mentioned the advent of transistors, which depend on non-metallic conduction; however, his Address was not primarily concerned with transistors as such, and he described how many other practical devices which the electrical engineer already uses depend also on that form of conduction. A short summary of the Address appears on page 23.

After the Chairman's Address, a vote of thanks was proposed by Mr. H. Stanesby and seconded by Dr. R. C. G. Williams. Dr. E. C. S. Megaw and Mr. G.

Millington moved and seconded a vote of thanks to Mr. J. A. Smale, the retiring Chairman.

SUPPLY SECTION

Chairman's Address

In 1948 the name and scope of the Section was changed from the Transmission Section to the Supply Section, and Mr. J. D. Peattie's accession to the chair is of particular interest since he is the first Chairman to be representative, in the broadest sense, of "Generation." The first meeting of the session, at which Mr. Peattie delivered his Chairman's Address, was held on the 27th October, 1954.

Mr. Peattie gave the wise recommendation that Dr. Ferranti's Presidential Address, delivered 44 years ago, could be read with advantage by engineers to-day, and he traced the development of power supply in Great Britain since the time of that remarkably prophetic discourse to the present day.

He mentioned the possibilities of large-scale electrical smelting of iron ore and pointed out that the idea was now considerably more attractive than when it had been adumbrated by Ferranti, owing to the ever-decreasing availability of hard coking coals and the proportionally increasing availability of the small, high-ash-content coal which is used for electric power generation. Ferranti, in 1910, had deplored the lack of progress in main-line railway electrification, and Mr. Peattie, with admirable restraint and succinctness, indicated that there were no grounds for self-satisfaction in the fact that the position to-day was almost unchanged. A short summary of the Address appears on page 23.

Mr. Peattie's philosophic and scholarly Address throughout stressed the need for a bold outlook in planning and concluded with the reminder that we are still, in effect, only scratching the earth's surface for our sources of energy supply.

A vote of thanks to Mr. Peattie was proposed by Mr. P. J. Ryle. The meeting, which was honoured by the presence of the President, terminated with a vote of thanks to the retiring chairman, Dr. L. G. Brazier, for his able direction of the Section during a most successful year, the vote being proposed by Mr. C. M. Cock and seconded by Dr. J. R. Mortlock. P. J. R.

UTILIZATION SECTION

Chairman's Address

At the first meeting of the new session on the 21st October, 1954, the new Chairman, Mr. J. I. Bernard, delivered his Address, for which he took as his subject *Educating the Public*; this, as is well known, is a matter to which he has devoted the larger part of his professional career. With such a theme at his disposal, he was able to introduce a very large number of selections from the Utilization Section's extensive repertoire, but here it must suffice to refer only briefly to a few of the compositions which seemed to him to require a little more patronizing.

In this connection, he recalled the view of Colonel Crompton, over 60 years ago, that a primary duty of every electrical engineer was to educate the public in the use of electrical energy, and made a very pertinent point when he expressed the opinion that to-day electrical engineers are so absorbed in their own particular problems that they often forget that many of their solutions might equally be of great assistance to other members of the community.

In referring to the important advantages which electricity can play with respect to better materials handling, he very rightly stressed that "it cuts out the 'coolie labour' kind of work on which British workmen should not be engaged in the second half of the 20th century." When dealing with industrial heating by electricity, he reminded his audience of a fact, the full potentialities of which are not always really appreciated. This is that, unlike other fuels, there are at least five different methods by which electricity can be employed for heating purposes, namely arc, contact resistance, induction, dielectric loss and the passage of current through a resistance element.

Mr. Bernard discussed many other aspects of "Educating the Public" such as clean food preparation, the use of electricity in hotels, and plugs and socket-outlets. A short summary of his Address appears on page 24.

After the Address of the Chairman, a vote of thanks was accorded to him. The meeting ended with a vote of thanks to the retiring Chairman, Mr. B. L. Metcalf, for all the work he had done for the Section during his term of office, and the presentation to him by Mr. Bernard of a Certificate of Chairmanship. R. H. R.

CONFERENCE OF HONORARY SECRETARIES OF STUDENTS' SECTIONS

The Annual Conference of the Honorary Secretaries of Students' Sections took place in the Institution building on the 11th and 12th November, 1954. Secretaries or other Committee delegates of all but one of the Students' Sections were able to attend the Conference, and present also were Mr. J. H. Reyner and Mr. E. M. Hickin, the Editor and Assistant Editor of the *Students' Quarterly Journal*. The Secretary of The Institution was in the chair. There were many topics under discussion, some of which were Meetings, Social Functions, Premiums, Papers, and Publications; the questions of Students' Summer Meetings and the Decline in Student Membership were particularly keenly discussed. The Conference made various recommendations that will be considered by the Council, but apart from the discussions leading up to these, many of the delegates found the exchange of ideas on running Section activities most helpful. The Secretary took the opportunity of explaining the background to the changes in the Examination Regulations, and Mr. Reyner outlined the policy for publishing

Students' papers in the *Students' Quarterly Journal*, which has recently been expanded.

For some of the members this was their first visit to Savoy Place and even, for one or two, to London. On the second day of the Conference, the members attending it were shown the Institution building, and the way in which The Institution's Secretariat operates. Many of those who had travelled far were glad to have the opportunity of seeing something of London over the week-end.

NORWICH

DISTRICT MEETING

The first meeting of the session in Norwich took place on the 11th October, 1954, when Mr. D. P. Sayers presented the paper entitled *The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems*, written by him in collaboration with Monsieur M. E. Laborde and Mr. F. J. Lane. Mr. J. A. Sumner occupied the chair.

After describing the great number of investigations, both theoretical and practical, which had been made, the speaker emphasized that there were still a number of problems to be solved and that the paper was an interim report on the subject.

That the large audience was keenly interested was clear from the length of the discussion, which continued long past the normal finishing time. In proposing a vote of thanks to the speaker, Mr. W. S. Kelly said that they felt honoured that Norwich was the first place outside London to have this important paper read in it. J. A. S.

OXFORD

DISTRICT MEETING

An interesting meeting was held at Oxford on the 10th November, 1954, when a paper was read by Mr. K. E. B. Jay, of the Atomic Energy Research Establishment, Harwell. Mr. J. R. Catlin was in the chair.

Mr. Jay, who is the author of *Britain's Atomic Factories*, gave a description of the factories for the production of fissile material designed, built and operated by the Industrial Group of the Atomic Energy Authority. He outlined the manufacturing processes and commitments of each establishment and the technical difficulties associated with the extraction, refining and manufacture of uranium into fuel elements for reactors.

The Windscale piles and ancillary ventilation and handling plant were next described in some detail, with a general account of the Calder Hall power-generating nuclear-reactor installation.

When dealing with the general question of power generation by the use of nuclear fuels, Mr. Jay mentioned the part that fast reactors may play in any future programme. He emphasized that the main problems at present were associated with the metallurgical and engineering development of suitable fuel elements. Coloured lantern slides which were used to illustrate the paper showed some safety aspects of the new industry.

The vote of thanks proposed by Mr. J. W. Boyce was enthusiastically supported. J. R. C.

PLYMOUTH

SOUTH-WESTERN SUB-CENTRE

The Opening Meeting

At the opening meeting of the session, which was held in Plymouth on the 14th October, 1954, the Honorary Secretary formally presented his annual report. After this Mr. J. E. Flower, the retiring Chairman, introduced his successor, Mr. H. C. O. Stanbury. The new Chairman began his term of office by presenting to Mr. Flower, on behalf of the Sub-Centre, a copy of *The History of The Institution*, in recognition of the great contribution he had made to the success of the Sub-Centre. A similar presentation was made to Mr. Oxenham, who recently retired from the office of Honorary Treasurer after a record period in it.

Mr. Stanbury gave an Inaugural Address entitled *Telecommunications: a Review*, in which he drew on his experience as a Telephone Manager. He first described the problems of building up the telephone services and the general practices by which they were dealt with, and he showed how the rapid growth of demands on the service had accentuated these problems. Mr. Stanbury then considered recent technical advances in many directions and demonstrated modern types of cable and communication equipment.

As Mr. Axford pointed out in his vote of thanks, this lively and interesting review made an admirable start to the new session, and it was greatly appreciated by the large gathering of members. R. C. B.

RUGBY AND BANBURY

RUGBY SUB-CENTRE

The new session has made an excellent start in the Rugby Sub-Centre. The opening meeting on the 5th October, 1954, at which Mr. D. Edmundson gave his Chairman's Address, was well attended. At the first Ordinary Meeting on the 27th October, which was a joint one with the Rugby Engineering Society, the attendance was even greater: the lecture hall of the Technical College was completely full, and some people were unable to obtain admittance. The District Meeting at Banbury on the 2nd November, 1954, provided a most enjoyable evening.

For his Chairman's Address Mr. Edmundson took as his subject *The Changing Outlook in Electrical Measurements*, and he illustrated the Address with experiments and lantern slides. It was a pleasure to welcome to the

meeting Mr. A. R. Blandford, Chairman of the South Midland Centre, and Mr. G. S. C. Lucas, a local member of the Council; Mr. Lucas deputized for Dr. Willis Jackson, Vice-President, who at the last minute was unable to attend, and he presented premiums gained by members of the Sub-Centre and by members of the Students' Section.

The joint meeting with the Rugby Engineering Society took the form of a symposium on servo systems, at which a number of authors gave short lectures on particular aspects of the subject. Mr. A. Asbury talked on *The Closed Loop versus the Open-Loop Servo*, Mr. F. B. Levetus on *Hydraulic Servos of both the Closed- and Open-Loop Type*, Mr. R. Peters on *Servos for Steam Governors*, Mr. A. A. L. Bentall on *Rotary Amplifiers*, and Mr. E. S. H. Dale on *Magnetic and Electronic Servos*. There was a break for coffee between the papers and the discussion, which unfortunately had to be cut short at 10 p.m., since it was then necessary to close the meeting.

Mr. D. Edmundson repeated his Chairman's Address at the District Meeting in Banbury. Full advantage was taken by those present to raise points in the discussion which followed the Address. There were not many members at the meeting, but it was a very friendly occasion and all those present thought the evening was well worth while.

Arrangements are in hand for the Annual Ball, which is being organized jointly with the Rugby Engineering Society. This will again be held at Chesford Grange, on the 25th March. E. S. H.

SHEFFIELD AND SCUNTHORPE

SHEFFIELD SUB-CENTRE

The Sub-Centre opened the session on the 20th October, 1954, with the introduction of the new Chairman, Mr. F. L. Parkin, B.Sc.(Eng.), who delivered his Chairman's Address on *Trends in Steel-Works Electrical Equipment*. This was most interesting, covering as it did all aspects of electrical equipment in a steel works. Such equipment is the large reversing motors for the blooming mills, billet-mill drives, cranes, lighting and communication apparatus, in connection with which Mr. Parkin considered the use of carrier-frequency and radio communication for controlling shunting locomotives. The meeting was extremely well attended, and a vote of thanks was proposed by Dr. F. A. Benson.

The second meeting was held at Scunthorpe on the 27th October, when the paper *Electricity Distribution in an Iron and Steel Works* was presented by Mr. E. C. Slater and Mr. T. B. Rolls. The paper described in some detail the reasons for various decisions made during the design of the distribution system in a large modern steel works, and was excellently illustrated by lantern slides. This paper was of particular interest to the members in the Scunthorpe area because of the heavy steel works situated there, and the meeting was well supported by members and friends. The Sub-Centre Committee much appreciated the Education Committee's permission to use the main hall of the new Technical College at Scunthorpe.

On November 17th the Sub-Centre was fortunate in hearing a paper read by Mr. J. W. Bunting, B.Sc.(Eng.), entitled *Safety in the Use of Portable and Transportable Electrical Equipment in Industry*. This meeting was held in the Mining Lecture Theatre of the University of Sheffield, because the usual meeting place at the Grand Hotel was not available, and the Committee are most grateful to the University for the loan of the Lecture Theatre. The paper was full of interest and provoked a wide discussion, including a very useful contribution from Mr. Fordham Cooper on the subject of artificial respiration in cases of electrical shock. G. G. N.

STAFFORD AND STOKE

NORTH STAFFORDSHIRE SUB-CENTRE

The first meeting of the session was held at Stafford on the 11th October, 1954, when Col. C. E. Calveley, the retiring Chairman, formally welcomed three new Corporate Members. Col. Calveley then invited Mr. A. R. Blandford to speak, suggesting that as Chairman of the South Midland Centre and a member of the Sub-Centre, he needed no introduction. Mr. Blandford said he had closely watched the admirable progress of the Sub-Centre from its inception and he had been particularly interested in the formation of the Students' Section. He quoted figures indicating that Students and Graduates comprised about 60% of the Sub-Centre membership and thought this was a very healthy sign for the future. He hoped the present enthusiasm and activity of the Students' Section would continue. In wishing continued success to the Sub-Centre he also mentioned that a premium had been presented to Mr. A. B. J. Reece and the Hooper Memorial Prize to Mr. A. P. Baines.

Col. Calveley next invited Mr. J. M. Ferguson to deliver his Chairman's Address on *Considerations in the Design of High-Power Pulse Generators*. With the aid of films, slides, and demonstration equipment Mr. Ferguson described the behaviour of pulses of energy, ranging from those provided by flywheels and switchgear-testing alternators to those used in radar and similar work. In formally thanking the Chairman, Mr. J. H. Pirie referred to his inspiring Address and the breadth of vision and engineering ability demonstrated by his choice of subject and his handling of it. He also expressed appreciation of the services which Mr. Ferguson, as one of the founder members, had already rendered to the Sub-Centre.

After Mr. Ferguson had taken the Chair, he proposed a vote of thanks to Col. Calveley, and recalled the fascinating meeting a year ago when Col. Calveley had used a great range of demonstration apparatus, all of which worked very well. He said that the retiring

Chairman also had worked very well throughout the session and expressed appreciation for the time he had given and the able way he had conducted affairs.

The Chairman then announced the resignation of the Sub-Centre Secretary, Mr. E. S. Johnson, on leaving the district, and the appointment by the Committee of Mr. W. G. Friggens to fill the vacancy for the remainder of the session. He warmly acknowledged the enthusiastic and untiring work Mr. Johnson had done for a number of years as Assistant Secretary and Secretary, and was pleased that he was present to hear the expressions of gratitude.

Mr. Blandford then presented mementoes in the form of copies of *The History of The Institution* to Col. Calveley and Mr. Johnson.

At the Stoke meeting on the 29th October, the Chairman formally welcomed a new Corporate Member. Mr. Ferguson then introduced Mr. T. E. Goldup, Vice-President, who said that he was particularly pleased to be present since he had unavoidably had to cancel his arrangements to visit the Sub-Centre on two previous occasions. He conveyed the President's good wishes for a very successful session and expressed the pleasure he personally enjoyed in meeting such a wide cross-section of the membership during his visits to the various Centres and Sub-Centres. He described a District Meeting he had attended and he was sure that any effort the Sub-Centre might make to foster such meetings, in order to bring more interest to small outlying groups, would be well repaid. The active discussions which such small informal meetings provoked proved to be very beneficial, and an enthusiastic reception could be expected.

Mr. H. Leyburn then delivered his lecture on *Continuity of Electricity Supply*, which was illustrated by films and slides and which covered a very wide field. Speakers in the discussion accentuated the economic aspect and also referred to the important contribution made by the maintenance staff. Mr. A. R. Buttrey proposed a vote of thanks to the lecturer and referred especially to the advantageous use made of different colours in the slides and of slow-motion films in clarifying the details described. The lecture had been most interesting throughout and he felt that they all much appreciated the author's willingness to enter into a wide discussion of the subject, although he was giving a lecture rather than opening a discussion.

The Chairman drew attention to the Faraday Lecture *From Courier to Carrier in Communications* to be given by Mr. T. B. Terroni at Birmingham in January, 1955, and he asked for the support of all members of the Sub-Centre to help to ensure the success of this important public meeting.

L. G.

NEWS *from abroad*

HERE AND THERE

We hope to make "News from Abroad" a monthly feature, since to help in knitting together members the world over is surely one of the most important aims of this periodical. The Council's Oversea Representatives, and the Honorary Secretaries of Oversea Branches, Committees, and Joint Groups have all been asked to co-operate by providing not only information about local activities such as meetings and visits, but also accounts of interesting or unusual experiences of members, and of local electrical engineering events which are felt to be of general appeal. We also invite those members who live in countries where there is no organized fraternity of The Institution to send contributions to the *Journal*. Photographs of interesting engineering events or equipment are welcomed, and will, wherever possible, be published.

It may surprise some readers to know that there are members of The Institution in practically every country in the world; in all some 7 000 members have permanent or temporary addresses outside the United Kingdom in 96 different countries. Many of these are able to obtain some of the services provided by The Institution, and in turn themselves to assist its affairs, by attending the meetings organized by the Oversea Branches and Committees; some can play a similar part through one of the Joint Groups of the three Engineering Institutions; yet others can join in the activities of one or more of the 27 engineering societies with which The Institution enjoys reciprocal arrangements for visiting members. As would be expected, however, some Oversea Branches and Committees are more active than others in arranging meetings. Distance and density of population influence such activity; however, most members living within the area of an Oversea Branch or Committee are given ample opportunity to meet other members, to take part in meetings and discussions, and to hear talks from senior engineers visiting the area.

As many members know, a map showing the organization of The Institution oversea is included in the booklet *The Institution: Its Objects and Organization*, which is issued to all new members.

The Joint Groups

Among the most active of the oversea units are the Joint Groups. These have been developed since 1945 and they aim at catering for the needs of members of

the three Institutions in those places where there are insufficient members to warrant the setting up of separate Branches. At present there are five Joint Groups—the Argentina, the Hong Kong, the Iraq and Persian Gulf, the Singapore/Malayan, and the West African.

The Argentina Joint Group is passing through a difficult period, and, unfortunately, it is not now so thriving as it was when it was first formed.

The Hong Kong Joint Group operates in conjunction with the Engineering Society of Hong Kong, and combined meetings are often held.

Meetings of the Iraq and Persian Gulf Joint Group take place in Basrah, Baghdad and Kuwait; the Group Committee have also in mind the possibility of holding meetings in Bahrein and Kirkuk. Each meeting lasts for two days, a paper being read on the first day, and a visit taking place on the second.

The Singapore/Malayan Joint Group holds meetings at frequent intervals in Singapore, and visits are also arranged from time to time. An extension of activities to provide for members "up country" is under consideration.

The West African Joint Group is the youngest of the Joint Groups, having been formed quite recently. Like the others it has been a great success and there have been a number of meetings in Lagos. A Sub-Committee has been set up in Accra and will arrange meetings for members on the Gold Coast.

Most members visiting England from abroad make a point of coming to the Institution building. Among those who have called to see the Secretary in recent months are Mr. D. P. Bennett, the Oversea Representative for Ceylon, and Mr. S. Rajanayagam, Vice-Chairman of the Ceylon Branch, who was on a six-month tour of the United Kingdom and the Continent. Mr. V. J. F. Brain, Oversea Representative for New South Wales, and Professor C. E. Moorhouse, the new Oversea Representative for Victoria and Tasmania, have also been in Britain for some months and are returning to Australia via the United States. Other Oversea Representatives who have visited Headquarters during the past few months include Mr. A. C. Towers (Argentina), who had not seen the United Kingdom for over 40 years, Mr. C. G. Downie (Cape Province), and Monsieur M. E. Laborde (Deputy Oversea Representative for France). Monsieur Laborde took part at an Ordinary Meeting in the presentation of the paper entitled "The Possibilities of a Cross-Channel Power Link," which he had written in collaboration with Mr. D. P. Sayers and Mr. F. J. Lane; this paper was awarded the John Hopkinson Premium. From the Far East, visitors have included Mr. J. Sharples, the Oversea Representative for Malaya and Singapore, Mr. W. G. Scott, a Vice-Chairman of the Singapore/Malayan Joint Group, Mr. W. E. Trafford, the Honorary Secretary of the Joint Group, and Mr. C. H. Mellor, the Oversea Representative for Burma. Mr. H. D. Walden, the Oversea Representative for the West Indies, was a visitor at Headquarters, and Mr. J. A. C. King, who serves on the Committee of Iraq and Persian Gulf Joint Group Committee, called to discuss the affairs of this Group. A list of members that have recently signed the Oversea Attendance Register appears below.

Among senior members who have travelled abroad recently are the President, Mr. J. Eccles, and Mr. T. E. Goldup, who have been to the United States and Canada; Sir John Hacking—to South Africa, New Zealand and Australia; Sir George Nelson—to South America; Mr. J. R. Beard—to South Africa and Rhodesia; Mr. S. L. M. Barlow—to the West Indies. In most places it has been possible to arrange for these members to address meetings of local members and thus strengthen the links between members at home and oversea. Members who live in the United Kingdom and whose duties take them abroad are reminded that the Secretary can provide letters of introduction to the Honorary Secretaries of the Oversea Branches, Committees, and Joint Groups and to the Oversea Representatives.

Members visiting the United Kingdom can be assured of a cordial welcome by the Institution staff, who will provide them with details of forthcoming meetings in London and the provinces and give such other assistance and advice as is within their power.

BAGHDAD

IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

The Iraq and Persian Gulf Joint Oversea Group took advantage of the British Trade Fair at Baghdad to hold their November meeting in the City of the Caliphs. Some 40 members from Bahrein, Kuwait, Basrah, Habaniyah, Kirkuk and, of course, Baghdad attended, including the only lady member in the Group, Mrs. Betty Sherman, A.M.I.E.E.

The British Electrical and Allied Manufacturers Association very kindly gave the proceedings a good start by putting on a cocktail party at the Semiramis Hotel, Baghdad, on the 4th November. Mr. Alec Henderson, the Secretary of the B.E.A.M.A. Middle East Committee, had been warned that at least 50 members and guests might be expected. However, they numbered nearer 200 before the proceedings finished, long after the intended time. Among those present were Lord Dudley Gordon, Past-President of The Institution of Mechanical Engineers, and Sir Norman Kipping, Director-General of the F.B.I.

In the evening the Group visited the very impressive British Trade Fair, at which most of the big British Engineering companies had tried to outdo each other in the excellence of their exhibits (not to speak of their hospitality).

On the 5th November the members of the Group were entertained at the Mansur Club, which adjoins the grand stand of the race-course, and two well-known electrical engineers, from Kuwait and Baghdad respectively,

managed to pick a couple of winners each. After lunch in bright sunshine on the lawn of the Club, the party adjourned to the Lecture Hall, where an admirable talk was given by Mr. Bernhardt, who represented a well-known British radio manufacturing firm. Mr. R. C. Kelt welcomed the members and introduced the speaker. In the evening the members met again at the Trade Fair and saw a practical demonstration of television, which concluded a most interesting and enjoyable meeting.

J. H. M.

CEYLON

Mr. C. B. H. Beadman, past Vice-Chairman of the Ceylon Branch of The Institution and a member of the present Committee, has been away on a tour of Australia.

On the 20th October, 1954, Mr. G. S. Ramaswami, one of the experts secured by the Ceylon Government under the Colombo Plan, who works with the Madras Government Electricity Department, gave an important address to members of the Branch, on the subject of rural electrification. He made a brief survey of the Grid system in South India and then referred to a typical scheme of rural electrification carried out by the Madras Government Electricity Department. Giving considerable technical data about development in rural electrification in Madras as well as in other Indian states, he compared them with data for Russia, France, Sweden, Poland, Italy, Romania, and Ceylon.

Mr. Ramaswami stated that neither the American nor the British practice of rural electrification was suitable for India and that as the conditions in Ceylon were similar to those in India, the 3-phase 11 kV distribution system adopted in India would be suitable for Ceylon. He also emphasized the fact that, unlike many comparable schemes in America or the United Kingdom, rural electrification schemes in India were paying propositions. Considerable power was required for pumping, irrigation, dairy and poultry farming, and other agricultural industries. On rural schemes in India the domestic and street lighting formed only a small proportion of the power load. Mr. Ramaswami projected a typical layout of a rural electrification scheme on the screen, and stressed the importance of keeping down costs to a minimum and of hiring out apparatus to farmers at very low charges. The cost of rural electrification in Madras had been only 5 900 rupees per mile. This low cost was made possible by the use of treated wooden poles or second-hand rail poles for carrying the transmission and distribution lines. Much standardization had also been carried out. Mr. Ramaswami said that 80% of the electricity used rurally was for productive purposes, and that, out of 35 000 villages in South India, over 2 000 now have electricity. The financial return had been as high as 16·2%, and he was certain that rural electrification would pay in Ceylon as well.

Many distinguished guests, including Mr. M. F. de S. Jayaratne, Permanent Secretary to the Minister for Transport and Works, Mr. R. S. Isar, Deputy High Commissioner for India, and Mr. S. A. Shareef, Deputy Director, Colombo Plan Bureau, Technical Branch, were present to hear Mr. Ramaswami's address.

M. M. B.

PERTH

A joint meeting between local members of The Institution and members of the Perth Division of The Institution of Engineers, Australia, was held on the 18th October, 1954, in connection with Sir John Hacking's visit to Western Australia.

Sir John spoke on aspects of generation and Grid distribution in the United Kingdom. The enthusiasm with which the audience followed the talk was shown by the many questions which were put to Sir John afterwards.

Mr. N. J. Henry, Divisional Chairman of The Institution of Engineers, Australia, and Mr. J. B. Jukes, Vice-Chairman of the Western Australia Oversea Committee of The Institution, were joint Chairmen of the meeting. A vote of thanks to Sir John was moved by Mr. F. C. Edmondson and seconded by Mr. J. W. Young, Director of Works for Western Australia.

F. C. E.

OVERSEA ATTENDANCE REGISTER

During the period 1st October to 30th November, 1954, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

ABAZA, Sh. (**Cairo**).
BARKER, S. J. (**Pietermaritzburg**).
BARRACLOUGH, A., B.Sc. (**New York**).
BEADMAN, C. B. H. (**Colombo**).
BROACHA, R. H. (**Tatanagar, India**).
CHRISTIANSEN, W. N., M.Sc. (**Sydney**).
ELDER, J. A. (**Kuala Lumpur**).
HATTINGH, A. M., B.Sc. (**Mufulira, N. Rhodesia**).
MULDER, B. H. W., Dipl.Ing. (**Lagos**).
NICHOLSON, P. T., B.Sc., B.E. (**Sydney**).
OHN, M. T., B.Sc.(Eng.) (**Rangoon**).
OLIVE, S. F. C. (**Gold Coast**).
RAMACHANDRAN, P. N. A. (**Bombay**).
ROWSE, E. J. (**Pretoria**).
SIMPSON, G. F. (**Lagos**).
SMITH, D. H., B.Sc.(Eng.) (**Lagos**).
SUTTON, F. W. (**Nairobi**).
WALTER, N. E. (**Lagos**).
WINTER, Major F. (**Lagos**).
WOLSTENHOLME, P. G. (**British Columbia**).

MONOGRAPHS AND PAPERS
published separately this month

Separate Monographs and reprints of all papers published in the Proceedings are available at the price of 1s. 3d. each (post free). The inclusive charge for a copy of a paper allocated for reading at a meeting on separate publication and for a reprint of the paper and discussion (as published in the Proceedings) is 2s. 6d. (post free). This charge is made whether or not the reprint is required, but a reprint alone costs 1s. 3d., as noted above. However, separate copies of a paper allocated for reading are supplied free of charge 10 days before the first meeting at which the paper is to be read, whether in London or in the provinces. If a reprint also is required, a remittance should accompany the request. Reprints of a paper being read at a meeting cannot be issued before the paper and discussion have been published in the Proceedings, but they should preferably be ordered before or shortly after the paper has been read in London.

In an order, a Monograph or a paper can be specified completely by the Author's surname and the serial number of the paper. Those who wish to avoid making a separate payment for each Monograph, paper, or reprint which they require can obtain books of voucher labels, price 10s. each, containing 8 vouchers, on application to the Secretary.

A list of papers published in the January issue of Part B of the Proceedings appears under "Contents of the Current Issues of the Proceedings" on page 64, and the serial number of each paper and the month of publication of a digest in the Journal are included. Synopses of both Monographs and papers which will be published separately before the next issue of the Journal appear below, and unless otherwise stated, their date of publication is the same as this issue of the Journal. Monographs will be republished in Part C of the Proceedings, and the relevant Part for the republication of a paper is given after the serial number of the paper.

MONOGRAPHS

T. W. STRAKER, M.Sc., Ph.D.

The Ionospheric Propagation of Radio Waves of Frequency 16kc/s over Short Distances

MONOGRAPH No. 114 R

The Monograph describes a continuation of the investigations of Best, Budden, Ratcliffe and Wilkes on the ionospheric propagation of radio waves of frequency 16kc/s emitted from the Post Office sender GBR at Rugby, and observed at Cambridge, 90km away. The experiments over the period March, 1948, to October, 1949, have confirmed the tentative conclusions of the work done before the Second World War, and revealed some new and interesting effects.

Most of the observations were made on the abnormal component of the downcoming wave using the method developed during the pre-war investigations to isolate the downcoming wave and to make separate measurements on its amplitude and phase.

The observations showed that reflection took place from a height of about 72km by day and 87km at night, and that the daily cycle of phase change was related to a real change in the height of reflection. The apparent height of reflection usually varied in a regular and predictable way with the zenith angle of the sun. The total change of height in passing from midday to midnight was 16·8km in summer and 13·5km in winter. There was a marked seasonal variation of the amplitude of the downcoming wave, the variation of the daytime amplitude being different from that of the night-time amplitude. During the summer months the amplitude was closely controlled by the sun, but it was not related in any simple way to the zenith angle. The daily cycles of amplitude change and phase change appeared to take place independently. The sunrise effect on the amplitude occurred about one hour before the effect on the phase, the latter occurring about 9min after ground sunrise.

Some subsidiary variations of the phase and amplitude, which were regularly observed, were explicable on the assumption that reflection took place from two levels in the upper atmosphere. There was no clear evidence of waves reflected twice from the ionosphere.

A digest of the Monograph will be published in Part B of the *Proceedings*.

F. HORNER, M.Sc.

A Table of a Function used in Radio Propagation Theory

MONOGRAPH No. 115 R

This is a short, official communication from the D.S.I.R. Radio Research Station on the subject of the function

$$F(\omega) = 1 + 2j\sqrt{(\omega)}\varepsilon^{-\omega}\int_{-j\sqrt{\omega}}^{\alpha}\varepsilon^{-x^2}dx \quad .$$

Tables of the values of its real and imaginary parts are given.

A digest of the Monograph will be published in Part B of the *Proceedings*.

P. HAMMOND, M.A.

Leakage Flux and Surface Polarity in Iron Ring Stampings

MONOGRAPH No. 116

The Monograph deals with the conduction of magnetic flux through iron circuits magnetized by windings which surround only a part of the iron. The complete solution is obtained for an infinitely long hollow iron cylinder magnetized by a single current loop, and it is shown that surface polarity on the iron plays a dominant part in causing the flux to be substantially constant at all sections around the circumference of the cylinder.

Experimental evidence is brought forward in support of the theoretical investigation.

A digest of the Monograph will be published in Parts A and B of the *Proceedings*.

J. W. LYNN, M.Sc.

The Tensor Equations of Electrical Machines

MONOGRAPH No. 117 S

The two-axis equations of synchronous machines have been widely used in analysis of power systems under steady-state and transient conditions. It has been found, however, that when mechanical oscillations occur in the machines the use of other reference frames leads to equations which give a clearer physical picture of the phenomena.

Kron has developed general dynamical equations for electrical machines, in tensor form, so that these could be expressed with respect to a chosen frame of reference. In his presentation of the tensor equations Kron develops these from non-holonomic transformations. In certain equations he treats the "non-holonomic object" as a tensor. The Monograph by Mr. Lynn demonstrates in detail the mechanism of this change.

A digest of the Monograph will be published in Part A of the *Proceedings*.

A. TALBOT

Some Fundamental Properties of Networks without Mutual Inductance

MONOGRAPH NO. 118 R

Elementary methods, avoiding the manipulation of determinants, are used in the Monograph to prove theorems, not previously enunciated, on the voltage and current gains obtainable from a resistance network, and to deduce therefrom some properties of the algebraic expressions for the voltages and currents in the network. After a brief survey of known properties of general *LRC* networks, in terms of the complex frequency variable λ, the previous results are used to obtain properties of general networks without mutual inductance: in particular a simpler formulation and proof of properties of *RC* networks than those given in a recent paper by Fialkow and Gerst.

Finally, attention is drawn to a neglected paper of Kirchhoff, in which the foundations of the topology of networks were laid down, and use is made of Kirchhoff's results to obtain explicit expressions, not involving determinants, for the various network parameters.

A digest of the Monograph will be published in Part B of the *Proceedings*.

H. V. SHURMER, M.Sc., Ph.D.

A Direct-Reading Waveguide Standing-Wave Detector for use at Low Power Levels

MONOGRAPH NO. 119 R

A method is described of directly measuring voltage standing-wave ratios (v.s.w.r.) at a fixed input power and frequency by means of a directional coupler, in which the errors introduced by the coupler are compensated. The directional coupler is used to measure the power reflected by the load, which is a function of its v.s.w.r.

The main purpose of this development has been to afford a means of directly measuring the standing-wave ratio of low-level detector crystals. In this application it is necessary to have an input power level of not more than about 5μW, below which the v.s.w.r. is substantially constant, and it is required to measure v.s.w.r.'s of the order of 0·80 to an accuracy of $\pm 0{\cdot}01$.

Unless the coupler has infinite directivity and one arm is perfectly matched, an error is introduced into the measurement which depends on the phase of the voltage wave reflected by the load. Since it is difficult to obtain a tightly-coupled directional coupler suitable for use at low power levels (of the order of 5μW) in which the error due to imperfect directivity is negligible, the treatment adopted is to cancel out the voltage waves which produce the error.

An instrument developed on these principles is used to measure the v.s.w.r. of crystal rectifiers at 3·20cm over a range of power levels from 5 to 650μW. The accuracy is better than $\pm 0{\cdot}01$ from 0·90 to zero v.s.w.r.

A digest of the Monograph will be published in Part B of the *Proceedings*.

PAPERS

R. T. RUSHALL and J. S. SIMONS, B.Sc.(Eng.)

An Examination of High-Voltage D.C. Testing applied to Large Stator Windings

PAPER NO. 1771 S; PART A

The merit of a proposed non-destructive method of assessing the breakdown voltage of stator-coil insulation by means of high-voltage direct current is examined. The proposal is to measure the steady-state leakage current at successive increments of applied voltage and predict a breakdown value from the trend of the plotted results.

Laboratory tests applied to a range of specimens of sheet insulation, including a number with artificially-formed faults, indicate that the only breakdown which can be predicted by this method is that across air paths external to the specimen. Tests carried out on a complete high-voltage stator winding and on single stator coils give similar results. No assessment of slot-insulation quality is possible; the only increase in current, suggestive of approaching failure, results from end-winding leakage and discharge effects.

It is concluded that the high-voltage d.c. method of testing investigated has no valid basis for non-destructively indicating the state of the insulation of high-voltage machines.

C. J. N. CANDY, B.Sc.

Invector Method for Amplitude-Modulated Signals

PAPER NO. 1772 M; PART B

The paper describes a vector notation for amplitude-modulated alternating quantities. This notation enables vector expressions to be derived for the impedances, admittances and transfer ratios of electrical circuits, and these expressions in turn operate directly on the vector for the amplitude-modulated voltages and currents to give the vectors for the dependent variables in the circuit. The results obtained by this vector analysis are in a convenient form for the direct calculation of the output of a demodulator, for any general input to the circuit. Examples are given to show that when the modulation frequency is comparable with the carrier frequency the modulation (or signal) may be appreciably modified by impedances in the carrier channel. The paper includes a description of a complementary operational method, which enables the response of circuits to non-sinusoidal amplitude-modulated signals to be determined.

R. W. PALMER

Maintenance Principles for Automatic Telephone Exchange Plant

PAPER NO. 1777; PART B

The paper will be published on the 31st January.

The maintenance of the complex mass of equipment which constitutes the modern automatic telephone exchange requires to be different from that of most engineering plant, mainly because the finding of the faults is so much more difficult than their subsequent repair. A comparison of maintenance practices throughout the world needs first to be qualified by differences in the design of systems and plant. With this reservation, the experience in the British Post Office and abroad with overhauls, cleaning, routine testing, alarms and

monitoring devices is then reviewed and compared. This leads to the compilation of a pattern of maintenance effort in relation to the effect on service and reveals the many alternative methods of prevention, disclosure and correction of service failures. The relative efficiency of methods of reducing the number of plant faults or reducing the number of calls affected by each plant fault is then discussed, and it is suggested that there may be a drift from the old-established policy of routine preventive maintenance in favour of a flexible and qualitative policy to suit the local condition of the plant. At the same time, the design of maintenance aids appropriate to modern technical developments in switching systems is reviewed.

A. M. HUMBY, C. M. MINNIS, M.Sc., F.Inst.P., and R. J. HITCHCOCK, B.A.

Performance Characteristics of High-Frequency Radio-Telegraph Circuits

PAPER NO. 1787 R

The paper will be published on the 29th January.

The paper analyses operational data from several important long-distance radiotelegraph circuits, and the results are discussed in relation to solar and magnetic variations. It is shown, *inter alia*, that the lowest operational efficiency on radio circuits need not necessarily occur at the same time as the lowest level of solar activity.

some recent BOOKS

E. H. W. BANNER

ELECTRONIC MEASURING INSTRUMENTS

CHAPMAN AND HALL. 407 PP. £2 5S.

This will prove a useful reference book. Parts I and II give a very good account of the instruments, valves, rectifiers and other special devices which are available for inclusion in instruments. Parts III and IV, which describe instruments using these devices, cover a very wide range of instruments required in industry and by scientists generally. It is, perhaps, unfortunate that the book gives the impression of being comprehensive, when, although it is nearly so, there are, in fact, some notable omissions. For instance, no mention is made of instruments for gas analysis in the industrial field or of magnetometers in the geophysical prospecting field, both of which are electronic in character and very important commercially, probably more important than the radiation thickness gauge and many of the photo-electric instruments which are described in some detail. The book, indeed, contains very little about instruments for the chemical industry, which is a serious omission, since, of all industries, the chemical is the biggest user of instruments.

It is, of course, impossible to cover all instruments using electronic equipment in a book of 400 pages. Major Banner's book has a remarkably wide compass and will normally give anyone who consults it for some particular purpose a lead to where he can find fuller information. Because it covers such a large field, a book of this nature cannot be very detailed and must depend on the references to extend the information given. From this point of view the material is, in general, good, but there is some lack of balance: e.g. the radiation thickness gauge is given a whole chapter of 12 pages, while only one chapter of 26 pages is devoted to photo-electric measuring instruments, which form a very wide class indeed. Consequently, the latter chapter tries to cover so many instruments that much of it is too general to be useful, and the detailed descriptions of individual instruments are very difficult to follow. This applies in other parts of the book where an attempt is made to go into detail, e.g. about the pH-meter. Major Banner could have saved some space by avoiding recapitulation in Part III of what he has already said in Part II. This is usually by way of amplification but it is disconcerting to the reader who recognizes that he has seen it before. With the division of the book into the two sections, the first on devices and the second on complete instruments, it is, of course, difficult to avoid this; and for a reference book this division is undoubtedly the most convenient.

Unfortunately, there are rather a large number of misprints and it is confusing to use a superior "B," instead of a numeral, to refer to items in the bibliographies, which are conveniently provided chapter by chapter. In a number of places symbols are used without any indication of their meaning. There are a few technical errors in the text: e.g. on page 238 the description of a photoelectric potentiometer is incorrect, cause and effect having been interchanged. In descriptions of classes of instruments there are some surprising omissions: e.g. in the chapter on amplifiers there is no mention of contact- or magnetically-modulated direct-coupled amplifiers, and, although Major Banner describes the electron microscope in considerable detail, he does not refer to the reflecting electron microscope, which is an important development.

It is to be hoped that, before this useful book is reprinted, the various misprints and minor omissions will be rectified. When this is done could the publishers please be consistent in the use of hyphens and the author avoid such neologisms as "circuiting" and "distinctive advantages"?

A. T. DOVER

ELECTRIC TRACTION

PITMAN. 3RD EDITION. 455 PP. £3.

There must be very few electric traction engineers whose training has not been inspired by previous editions of Mr. Dover's book; indeed, this work has always been regarded as a standard textbook on this subject, and the third edition will be no exception to this statement.

This modernized edition follows strictly on the lines of the previous ones, and it includes many revisions to the text and illustrations covering the advances made in rail and road electric traction over a period of 25 years. Necessarily, much material contained in the previous editions which is now more of historic than of practical interest has had to be omitted in order to achieve the revision.

The author has made considerably more use of page footnotes than before, to refer the research reader to Institution papers and other sources. This contributes much to the value of his work as a reference book, although, probably, the index fails to support the text and illustrations to the extent that these merit and a quick reference demands. On the other hand, so many traction engineers will be familiar with the chapter sequence and the many landmarks remaining in the form of illustrations and diagrams that, for them anyway, it may be argued that an index is not important. These illustrations and diagrams cover a wide period, so wide indeed that the student may well seek more guidance as to the extent to which some indicate the trend of modern practice.

Perhaps too much emphasis has been put on the use of frame-mounted, i.e. entirely sprung, d.c. motors for high-speed locomotives and the use of a flexible drive for a gas-turbine locomotive; there are large numbers of axle-hung d.c. motors which are giving excellent service on Diesel-electric locomotives throughout the world, many of which incorporate unsprung drives.

Line equipment work is treated rather too briefly in Chapter XXIV, and some would consider a shift of emphasis desirable. As an example, two pages are devoted to the calculation of dropper length but no mention is made of the important bearing that wire deflection due to wind has on span length. A few misleading statements were noticed in this chapter: e.g. on page 372 a simple catenary system is defined as "a steel wire from which a trolley wire is supported," although many systems—certainly most d.c. ones—have a copper or bronze catenary; again, on page 378 the author states that present Swiss Railway construction uses channel and angle sections for structures, whereas this construction has now been abandoned in favour of the simple beam mast shown in the illustration on the same page.

It is a pity that the Table on page 355 giving data on steel rails does not include the new British Railways standard flat-bottomed sections. In addition, the importance of the impact of different systems of electrification upon track circuits and telecommunications, or, referring to rolling-stock, even the complications so often encountered with the auxiliary equipment of the modern multiple-unit train, would seem to deserve more space. But the author has had to stop somewhere in his treatment of the expanding work of the traction engineer, and he rightly acknowledges this in his preface to the new edition.

Much credit is due to the author for covering so much new ground within a smaller volume than before, without detracting from the importance of the old material; he has covered this new ground to the limit fixed by present experience. He is to be congratulated on meeting a growing interest in electric traction with a comprehensive textbook that will be useful to student and engineer alike. It is of handy size and, considering the large number of illustrations it contains, it is reasonably priced.

JOHANNES PETERS

EINSCHWINGVORGÄNGE, GEGENKOPPLUNG, STABILITÄT. *Theoretische Grundlagen und Anwendungen* (TRANSIENT PHENOMENA, FEEDBACK, STABILITY. *Theoretical Principles and Applications*)

BERLIN: SPRINGER-VERLAG. 193 PP. 27 MARKS.

The present book of five chapters has grown out of one originally intended to deal only with the more restricted theme of the feedback amplifier. The first three chapters serve as an introduction to the theoretical basis of the subject and begin with a general treatment of the static and dynamic properties of linear transmission networks. The author presents enough of the elements of function theory to explain the various area theorems for impedance, and for the phase and modulus of a transmission function. Dynamic network properties are characterized by Fourier and Laplace transforms, the opportunity being taken of showing how the law of causality helps to resolve time paradoxes. The author devotes a special section to carrier-frequency systems and the transformation between low- and band-pass systems. He gives an example of the detailed calculation of the transient response of the i.f. amplifier of a television set.

The subject of the second chapter is network analysis and the author chooses to confine himself to the nodal method. Matrix representation and the properties and limitations of matrices are explained with the aid of many very attractive and lucid diagrams. In particular the concept of the equivalent circuit is meticulously considered. The causes of instability and the various well-known criteria for exposing it are followed, in the third chapter, by a brief summary of the means adopted to stabilize an amplifier.

The fourth chapter, on the feedback amplifier, begins with characteristic curves of non-linear devices and the parameters used to describe non-linearity. The block diagram of the amplifier and its auxiliary input- and output-matching and feedback circuits appears at first sight to be unnecessarily complicated, but the reader will appreciate the wisdom of this almost pedantic representation when the various practical methods of applying feedback are examined. The use of feedback to reduce the effects of variations in gain, to linearize a complete family of characteristics and to modify terminal impedances are all explained in detail. The different effects of feedback on disturbing voltages which arise in the amplifier but are either controlled by, or independent of, the signal are carefully discussed. In this connection the limitations of dynamic range of the amplifier are stressed. Multiple-path feedback schemes are shown in general to be unprofitable, but the author analyses in detail the special case of the cathode-coupled pair. He describes feedback as a transformation which enables superfluous performance in one direction to be exchanged for improved behaviour in another.

The final chapter deals with mechanical, electrical and electromechanical, transmission systems. The analogies between mechanical and electrical circuits are tabulated. Transducers and transformers are compared, and the discussion extends to distributed mechanical systems and thermal effects.

At the end of each chapter there is a summary of its contents which forms a most satisfying coda to each section of the work. Any profound publication covering this field must inevitably be compared with Dr. Bode's well-known book and the author acknowledges his debt to it. In two respects, in the opinion of the reviewer, Herr Peters's book is an improvement in that the explanations are more lucid and the diagrams better drawn. It may be unreservedly recommended to the professional engineer with a knowledge of German. He will appreciate the careful attention paid to the more *recherché* aspects of amplifier design. The post-graduate student should find that the inclusion of the introductory matter on circuit theory makes the book sufficiently self-contained. A bibliography of 140 items gives references to books and papers up to 1953.

THE INSTITUTION EXAMINATION

List of Successful Candidates

This examination was conducted jointly by The Institutions of Civil and of Electrical Engineers.

Success in the examination does not in itself qualify the candidate for Associate Membership.

JOINT PART 1 (NEW REGULATIONS), APRIL 1954: BRITISH ISLES

THE FOLLOWING HAVE SATISFIED THE EXAMINERS IN THE COMPULSORY SUBJECTS OF JOINT PART 1 (MATHEMATICS, APPLIED MECHANICS, HEAT, LIGHT AND SOUND, PRINCIPLES OF ELECTRICITY):

AFFLECK, Gerald Gordon.†
ANDREW, John Leslie.†
APPLETON, Alan Andrew.†
BAILEY, Michael Edward Owen.†
BALDRY, John Anthony.
BARROW, Michael John.†
BATE, John Livesey Hender.†
BATH, Hubert John.†
BATLEY, John Geoffrey.†
BEDAWI, Mahgoub el.†
BENNEY, John Harvey.†
BEUSMANS, Derrick Matthew.†
BEWEY, Walter George.†
BHARGAVA, Dinesh Chandra.
BIRCHALL, Robert M.†
BLACKER, George Allan.†
BLEWETT, Thomas Tonkin.
BLOODWORTH, Reginald S.*
BONNERJEE, Bibekananda.
BOWYER, John Spalding.†
BROOKS, Colin.†
BROOKSBANK, William.†
BROS, Peter Michael.‡
BROWNING, David Royden.†
BRYAN, Alfred Ernest.*
BURKITT, Timothy John K.†
BURNLEY, Derek Hewitt.†
CHARI, M. Venkata Krishnama.*
CLARE, Edward Lewis.†
CLAYTON, Cyril Edwin.
CLEARY, Alan.
CLYDE, Ronald Buchanan.
COX, William Jabez George.
CRACKNELL, Reginald Claude.*
DALLOW, Raymond William.
DAVIES, Alan John.†
DEB, Benoy Krishna.*
DIMERY, Peter John.†
DIXIT, Gadadhar Bapu.
DIXON, John Hesford.†
DRIVER, Eric Ronald.
DUGUID, George William A.
DYER, William Gilbert.†
EVANS, John Vivian.†
GALLON, John Alfred.†
GILL, Allan Charles.†
GRAY, John Edward.
HALL, Harry.†
HAWKINS, Frederick John.†
HERRICK, David William.†
HOBBS, John Michael Somerset.†
HOLDEN, Leslie Norman Barry.†
HOLDER, Edward Henry Mark.
HUTCHINS, Peter Frederick G.†
IBRAHIM, Murtada Ahmed.†
ILIFFE, Frank Joseph.†
JAMES, Ronald William Henry.†
JEFFERIES, Donald Grant.†
KAMAL, Mohsin.
KELKAR, Kishor Shridhar.
KIRKLAND, Geoffrey Paul.†
LAMB, Bernard Samuel.
LI, Yuan-Lu.
LIGHT, Francis Denis.†
LITTLE, George Duncan.†
LOVELUCK, Royston.
MacBRIDE, John Millar R.
MacMAHON, Charles Daly.†
MAGEED, Yahia Abdel.†
MARSHALL, Ernest John Harold.
MOBBS, Peter Harry.
MOFFAT, James Pringle.†
MOLE, Bryan Adamson.†
MORRIS, Bernard.†
MORTON, Eric John.†
NADARAŞA, Mailvaganam.†
NEILL, Thomas William R.†
NEWSON, Trevor Kenneth.†
NICHOLLS, Edgar James.†
OLDHAM, Thomas John.†
PETCH, Gordon Leslie.†
PINNELL, David Bevan.†
POUGHER, Clive Sydney.†
PREESE, Basil Griffiths.†
PRIEST, David Edward.†
RANDALL, John James.
RATHOR, Riaz Hussain.
RATTUE, George David.†
READER, David.†
ROBERTSON, David Stuart.†
ROCHE, Denis John.
RODDA, David Wyndham C.†
RULE, John Reginald.†
SANYAL, Ardhendu Sekhar.
SHAW, Cyril Martin.†
SHERWOOD, Robert Joseph.
SMITH, Alan Hugh.†
SMITH, Michael Ernest.†
SMITH, Trevor John.†
SOUTHWELL, Charles Alan.†
STEWARD, Peter Russell.†
TALBOT, William Allan Dyer.
THOMPSON, Eric.†
TURNER, Peter Allan.
VAZ, Eric Clement.*
WAKEFIELD, Peter.†
WALKER, Geoffrey.†
WALL, John Stevenson.†
WALLER, Richard de Warrenne.
WATTS, Grahame Duncan.
WEBB, John Henry.†
WHITEHEAD, Francis Michael.†
WILLIAMS, Hari.
WOLLEY, Charles William.†

* Also satisfied the examiners in the subject of English.
† Also satisfied the examiners in the optional subject of Theory of Structures.
‡ Also satisfied the examiners in the optional subject of Theory of Machines.

THE FOLLOWING CANDIDATES HAVE BEEN PERMITTED TO ENTER THE EXAMINATION UNDER SPECIAL CONDITIONS AND HAVE SATISFIED THE EXAMINERS IN THE SUBJECTS INDICATED:

ASHCROFT, John. d
BAIRD, John. d
BROWN, Albert Geoffrey. d
CAMPBELL, Ronald George A. d
CHALLENOR, Dennis. c, d
CHRISTIE, Angus Webster. d
CLARK, John. d
COLE, Eric Maxwell. c, d
COLLEY, Samuel Pearson. a
CORBEN, Frederick. d
DANGERFIELD, Leslie B. c, d
GARDENER, Guy Vallier. c
GRUMMITT, Claude Norman. d
GUSAU, Mallan Abdu. a, d
HALLOWAY, Roy. c, d
HAVRANEK, William Alfred. c
HIGGINS, Ronald Albert. c, d
HILTON, William George. d
HOSEY, Douglas James. b
HOWE, Frank Ralph. c
JEWELL, John Travis. a
JONES, Brian William. a
JONES, John Frederick. c
KENNELLY, Richard. c
KNIGHT, Leslie George. d
LOACH, Douglas Clifford. d
MERCER, George. d
MORRISON, John Gordon. d
MURCH, Leslie John. c
NORWOOD, John Frederick. c
O'MEARA, Brian Patrick. c, d
PARISH, Bryan Frederick. a, d
PRINGLE, John MacKintosh. d
REEVE, Alan John. a
SHAW, James Maxwell. a, c
STREET, Royston John. a, c
SWINDELLS, Trevor Davis. c
THORBURN, Samuel. b, c
THURLOW, Anthony Lawrence. c
VENISON, Kenneth Richard. a
WALKER, Christopher J. S. d
WINDSOR, Anthony Aiden. a, c

a Mathematics. b Applied Mechanics. c Heat, Light and Sound. d Principles of Electricity.

THE FOLLOWING CANDIDATES HAVE SATISFIED THE EXAMINERS IN THE SUBJECT OF ENGLISH:

BEDI, Pawan Kumar.
BRENNAN, Bernard Philip.
CLARKE, Russell.
COWIE, Alexander Grant.
DOUCH, Barrington Radcliffe.
FARRELL, John Joseph.
FRANK, Reinhard.
GILES, Anthony Russell.
HAWES, Gordon Peter.
HEGARTY, Noel Bertraund.
HOCKLY, David Alan.
HORNSEY, Donald Arthur.
JAMES, Balaprabudas.
McCULLOCH, John Arnott.
McDONALD, Brendan Anthony.
MANNING, Graham Erwin.
MUSSELL, Alexander.
O'SHEA, Gerard.
PADDOCK, Frederick John.
PHELPS, John Keith.
PITTS, Robert Henry.
SATYANARAYA, Kanagala.
SHAW, Francis Graham.
SKINNER, Peter.
SPALL, George William.
TULK, John Frederick.
WILSON, William John.

JOINT PART 1 (NEW REGULATIONS), APRIL 1954: OVERSEA

THE FOLLOWING HAVE SATISFIED THE EXAMINERS IN THE COMPULSORY SUBJECTS OF JOINT PART 1 (MATHEMATICS APPLIED MECHANICS, HEAT, LIGHT AND SOUND, PRINCIPLES OF ELECTRICITY):

AHLUWALIA, Daljeet Singh.
ANTHONY, Conganige M. M.†
BANERJEE, Ahi Bhusan.*
BANERJEE, Hironmoy.
BANERJEE, Tapan Kumar.
BASU, Jyotirmoy.*
BHAGAT, Manohar Nilkanth.*
BHARDWAJ, Amar Singh.
BHATTACHARYYA, Biman K.
BHOBE, Shriram Vishwanath.
BOCARRO, Leonard James.
CHATTERJEE, Amitabha.*
CHAUDHARI, Ramadas Natu.
DAS GUPTA, Anil Kumar.
DAS GUPTA, Dibyendu.
DAS GUPTA, Kalyan Kumar.*
DATAR, Sharad-Chandra G.*
DESAI, Mohanlal Ranchhodji.
DE ZOYSA, Lalithe Nihal.‡
DHARMARATNE, Dominic J.
FERDINANDS, Richard N.*
FONESCA, Edsel Martin.
FREDERICK, Jerome Ashbert.†
GANESAN, Mahesan.†
GHELANI, Narottam Topan.*
GHOSH, Panchu Gopal.
GHOSH, Ratanranjan.*
GNANASAMPANTHAN, Thambyrajah.
GONSALVES, Wilfred Joseph.
GOWARIKER, Shankar R.
GUHA, Sukumar.†
GULATI, Dayal Prashad.
GUNASENA, Malawiachchi G.
GUNEWARDENA, Wanusapperumaarachige D.
HATTANGADI, Anant Annaji.*
HO, Kwok Yu.*
HOLEY, Eknath Ramkrishna.
IBRAHIM, Mohammad.
IDRIS, Saiyed Mohammad.
ISSAR, Om Parkash.
JAIN, Sat Pal.
JOGLEKAR, Balkrishna Vinayak.*
KANAGALINGAM, Candiah.†
KHALIQ, Ghulam.
KHAN, Fazal Karim.
KHAN, Ghulam Ahmad.
KHAN, Mohammed Akbar.
KHAN, Mosim.*
KHANNA, Tilak Raj.*
KRISHNAMURTI, C.
KUNDU, Dilip Kumar.
KURUPPU, Upali Srimath.‡
LAL, Girdhari.
LAL, Sewak.
LI, Seung Ping.
LIN, Fam Seng.†
MADAN, Om Prakash.
MARZOOK, Mohomed Shariff M.‡
MEDHEKAR, Vasant Narayan.
MODAK, Hemant Gajanan.
MOHANA RAJA, Chiralayam A.
MUKHOPADHYAYA, Kali K.
NAIK, Anand Bhagwant.
NAIR, Parmeshwar Balram.*
NARWAY, Baboo Lal.
NATH, Kameshwar.
NUNNEY, Harold Desmond.*
OAK, Govind Gangadhar.*
PARAMADAS, Joseph.†
PARMAR, Shamsher Singh.
PARULEKAR, Waman Shankar.
PATHARE, Dattatraya Yeshwant.
PERERA, Ivan Hilarian.†
RAJAGOPAL, Kanthadai.
RAJAGOPALARAO, Patnayakuni.
RANA, Dilip Kumar.
RATNAWEERA, Ariyadasa.†
REGAN, James Henry.*
ROY, Asoke Kumar.*
SANGER, Ishwer Chender.*
SARKAR, Ashim Kumar.
SATAGOPAM, Pattam R.
SEEHRA, Kirpal Singh.
SEN, Premasish.
SENEVIRATNE, Mahinda E.†
SEN SARMA, Anjan Kumar.
SETHURAMAN, Panchabikesan.
SETHURAMAN, Rajagopalan.*
SHEIKH, Ghulam Muheyyuddin.*
SHENVI, Gurudas Anant.
SINGH, Kehar.
SIVARAJAH, Chelliah.
SOMANADER, Edward Peter.*†
SREEDHARAN, V.*
SRINIVASAN, Subrahmanyan.*
TENNEKOON, Kenneth Dudley.†
VERMA, Triloke Chand.
VIR, Raj Kumar.*
WICKRAMASURIYA, Jayasena.
WIGNARAJAH, Thiyagarajah.
WONG, Cheuk Chi.†
WONG, Mang-Ki.†
YUAN, Tao Ming.†

* Also satisfied the examiners in the subject of English.
† Also satisfied the examiners in the optional subject of Theory of Structures.
‡ Also satisfied the examiners in the optional subject of Theory of Machines.

THE FOLLOWING CANDIDATES HAVE BEEN PERMITTED TO ENTER THE EXAMINATION UNDER SPECIAL CONDITIONS AND HAVE SATISFIED THE EXAMINERS IN THE SUBJECTS INDICATED:

BEADLE, Peter Ralph. b
FLETCHER, Peter Roy C. a
HODGES, Gordon Francis. a
WALLIS, Jack Charles. b, c, d

a Mathematics.
b Applied Mechanics.
c Principles of Electricity.
d Theory of Structures.

THE FOLLOWING HAVE SATISFIED THE EXAMINERS IN THE SUBJECT OF ENGLISH:

ACHREKAR, Chandrakant V.
ADHIA, Jayantilal Jivraj.
AKINDIYA, Julius Oladokun A.
BEADLE, Peter Ralph.
BHAT, Somaje Mahalinga.
BHATI, Achloo Lal.
BOWMAN, Allan George.
DESHMUKH, Sharatchandra G.
DE SOUZA, Hannibal Mark S.
DHANABALASINGAM, Seenivasagam.
D'SILVA, Tarcisius Joseph.
FERNANDO, Gabriel Barbetus S.
GANGOPADHYAYA, Rabindra Nath (also known as Gangulee).
GNANASUBRAMANIAN, Papanasam Krishnaswamy.
GOONEWARDENA, Egodage Sangabo Dalton Thirsius.
GOYAL, Radhey Shiam.
GUPTA, Joginder Kumar.
GURUSWAMY, Sankara.
HOOGHAN, Naramolak-Singh R.
HORE, Lal Mohan.
JAIN, Gian Chand.
JAYAWARDENE, Wilmot J. C.
KHAN, Abdul Wahab.
KISHORE, P. Shah.
KOITA, Rahimbhai Kaderbhai.
KRISHNAN, V.
KRISHNASWAMY, Rangachari.
MEHTA, Indravadan Ambalal.
MILNE, Thomas Sinclair.
MISRA, Triloki Nath.
MUNJEE, Ariff Gulamhusein.
PALEKAR, Trimbak Narayan.
PARIKH, Ramesh Bhogilal.
PEIRIS, Mahathelge Oswald S.
PRASAD, Kikkeri Srinivasan.
RAJAGOPALAN, Pulavari S.
RAJARATNAM, Vivian Samuel A.
RAMADAS, Ramayyar.
RAMANUJAM, Rajagopalan.
RAO, Manohar Pandurang.
SAMADDER, Surendra Nath.
SATAGOPAN, Navalpakkam.
SENGUPTA, Dilip.
SETHUMADHAVAN, Anavangote.
SHANKAR SASTRI, Mylapore V.
SINGH, Dalip.
SITARAMAM, Nishtala.
SMITH, John Rainey.
SONI, Madan Lal.
SUBRAMANIAN, A.
TASKAR, Purshottam Dinkar.
TIKKU, Pearey Krishna.
TIN SI.
VARADARAJALU, Venugopal N.
VICTOR, Michael Lawrence.

SECTION B (OLD REGULATIONS), APRIL 1954: BRITISH ISLES

AMIN, Bhogilal Chunilal.
BEDI, Pawan Kumar.
BROADBENT, Frank.*
FROST, William Thomas.
IMLAY, Alan William.
JAMES, Balaprabudas.
KANDIAH, Ampalavanar.
KENNEDY, Joseph Mary F.
KIELY, Denis Martin.
MORTON, William Desmond.*
MYCROFT, George Herbert.*
O'KEEFE, John Francis.
ROGERS, Edward Charles.
SALEH, Ahmed.
SATYANARAYA, Kanagala.*
TAMBRA, Mohd Latif.
TAYLOR, Gordon William H.*
TIERNEY, Alphonsus Anthony.

* Satisfied the Examiners in Electrical Engineering only, having been granted exemption from the Special Subject.

SECTION B (OLD REGULATIONS), APRIL 1954: OVERSEA

BANERJEE, Amal Chandra.
BHATNAGAR, Satish Chandra.
BHATTACHARYYA, Shambhunath.
DESAI, Shashikant Hiralal.*
DE SILVA, Laddusinhabadu W.
GURSAHANEY, Motilal T.*
GWAL, Ramphal Badluprasad.
HILL, Derek James.*
JOSHI, Sharad Krishna.
KASARGOD, Sadanand Vithal.
KHATEEB, Iqbal Ahmed Alisaheb.
KUNDARGI, Arvind V.
LASKAR, Amulya Lal.
LYE, Fah Yew.*
MARFATIA, Indravadan Ishwarla.
MEHTA, Kishor Maneklal.
MEHTA, Parshotam Dutt.
RAMASAMY, Venkateswaran.
RAO, Ramappa Sridhara.
RAUF, Abdul.
RAY, Krishna Das.
SHAH, Manubhai Ambalal.
SIVAGNANASUNDERAM, Thuraisamy.
SONI, Kailash Chand.
SUBASINGHE, Subasinghe Arachchige Don Aryadasa.
SUHAYB, Kumar Tajuddin Farid.
SUKUMARAN, Gopalannair.
TAHIR, Mohammad.*
TALWAR, Manmohan Singh.
TAMASKAR, Dinkar Gopal.
TASKAR, Vasudeo Dattatrey.
THAMPY, Keralavarma Krishnan.
VENKATASUBRAMANIAN, Arunachala Ayer (also known as A. V. S. Mani).

* Satisfied the Examiners in Electrical Engineering only, having been granted exemption from the Special Subject.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 24TH DECEMBER, 1954

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	29	6 386	3	0
£5 to <£100	727	8 105	7	10
£2 to <£5	1 740	4 858	10	1
Under £2	15 485	8 444	1	5
		£33 794	2	4

THE FARADAY LECTURE

27TH JANUARY, 1955

Members are reminded that the Faraday Lecture will be delivered by Mr. T. B. D. Terroni, B.Sc., at the Central Hall, Westminster, on Thursday, 27th January, 1955, at 6 p.m., his subject being *Courier to Carrier in Communications*.

The primary object of the Faraday Lecture is to increase the interest of the general public in electrical matters, particularly those having an immediate bearing on the life of the community. **We therefore ask members to bring the Lecture to the notice of their friends.**

Admission is free by ticket obtainable from the Secretary; members are requested to enclose a stamped addressed envelope with their applications.

CONSTITUTIONS OF COMMITTEES, AND REPRESENTATIVES OF THE COUNCIL

The constitutions of various Committees of The Institution, including Oversea Branches, Committees, and Joint Groups, will be found on pages 57–61. The names of the Council's Oversea Representatives, and of their Representatives on other bodies (including the Council for Codes of Practice), and the constitutions of the Local Centre Committees, will be published in February or March.

PROGRAMME OF MEETINGS: SESSION 1954–55

The programme card of London meetings for the second half of the session is being sent with this issue to all members living in the following counties:

Bedfordshire
Berkshire
Buckinghamshire
Essex
Hertfordshire
Kent
Middlesex
Oxfordshire (less that part coming within the area of the South Midland Centre)
Surrey
Sussex (less that part coming within the area of the Southern Centre)

Members living outside this area will receive, in due course, the programme cards of the Local Centres to which they are attached.

Any member living in the provinces who often visits London, and is thus able to attend London meetings, may obtain a copy of the London programme card on application to the Secretary.

PAPERS READ AT MEETINGS

A QUESTION OF NOMENCLATURE

A paper accepted for reading at meetings, like a monograph, is first published individually and is republished in the *Proceedings* later. Originally, such a paper was issued only in time for the meeting, so that, if a manuscript was accepted after the current programme of meetings had been made up, it lay dormant, sometimes for several months.

To meet a growing demand for the early appearance of an author's work, it was decided in 1948 that a paper should be prepared for the press as soon as it had been accepted, and published as soon as it was ready. It was at first considered necessary to distinguish between a paper issued early, for which there is a small charge, and a paper issued 10 days before the meeting or thereafter, for which no charge is made. Thus it was that copies of papers published individually came to be known as "early proofs" and "meeting proofs."

Unfortunately, the term "proof" has turned out to be not quite the right word for a document which, although subject to minor corrections, is republished in the *Proceedings* substantially as it stands. It has therefore been decided that, from now onwards, there is to be no special nomenclature for papers that are accepted for reading at meetings. The announcement which appears elsewhere in this issue, under "Monographs and Papers published separately this month" distinguishes clearly between when a paper is charged for and when it is gratis, without calling it by any other name.

JOINT CONSULTATIVE COMMITTEE WITH THE ENGINEERS' GUILD

A Joint Consultative Committee has been set up between The Institutions of Civil, of Mechanical, and of Electrical Engineers and the Engineers' Guild, to consider matters of common concern and to report as necessary to the respective Councils.

ANNUAL INDEX TO THE JOURNAL

A few typewritten copies of the contents and index pages for the 1954 *Journal* have been duplicated on paper of suitable size, for the benefit of any members who propose to have their *Journals* bound. Until this small stock is exhausted, any member may obtain a copy on application to the Secretary.

In future, printed index pages will be distributed with the December issues of the *Journal*.

THE INSTITUTION OF ENGINEERS (INDIA)

The Annual Session of The Institution of Engineers (India) will take place in Hyderabad from the 19th to the 24th

The First Annual Dinner of the London Students' Section

February, 1955. This includes the 35th Annual General Meeting, Meetings for the Presentation of Papers, a Prestressed Concrete Exhibition, Technical Visits, and Social Events. Members of The Institution are cordially invited to attend the Session, and they may participate on the same terms as members of the Indian Institution.

EARLY RELEASE OF INFORMATION TO THE TECHNICAL PRESS

To enable the technical Press to publish as soon as possible new material of topical technical interest dealt with in papers accepted for reading before The Institution, an author of such a paper is at liberty to offer a more popular, less technical and shorter article for publication in the technical Press prior to the reading of his formal Institution paper on the same subject, provided that the article does not appear before the paper has been published separately (see page 47) and that the article makes reference to the paper.

Similarly, the author of a paper which has been accepted for publication only may proceed forthwith to prepare a more popular, less technical and shorter article for the technical Press, but it must not appear before the paper has been published in the *Proceedings* or as a *Monograph*, and it must be accompanied by a suitable acknowledgment.

DECLARATION ON FAIR COPYING OF SCIENTIFIC INFORMATION

The Institution, in common with more than 70 other scientific and learned societies, has subscribed to the Royal Society's Declaration on Fair Copying, which reads as follows:

We will regard it as fair dealing for the purpose of private study or research when a non-profit-making organization, such as a library, archives office, museum or information service, owning or handling scientific or technical periodicals published by us, makes and delivers a single reproduction of a part of an issue thereof to a person or his agent representing in writing that he desires such reproduction in lieu of a loan or manual transcription and that he requires it solely for the purpose of private study, research, criticism or review, and that he undertakes not to sell or reproduce for publication the copy supplied, provided:

1. *The recipient of the copy is given notice that he is liable for infringement of copyright by misuse of the copy, and that it is illegal to use the copy for any further reproduction.*
2. *The organization making and furnishing the copy does so without profit to itself.*
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The first Annual Dinner of the London Students' Section was held on the 16th March, 1905, and since then, in addition to a large number of dances and other social functions, the Section have held 32 Dinners. It is no longer customary to hold an Annual Dinner, and the main social event in each of the last three years has been a conversazione in The Institution building attended by about 250 members of the Section and their guests. Encouraged by such support, the Committee are arranging another conversazione on Friday, 11th February, particulars of which have already been sent to all members of the Section.

This date being near the 50th anniversary of the first Dinner, the London Students' Section Committee have decided to invite as their guests any surviving members who were at that Dinner. Unfortunately, it has not been possible to ascertain the names of all those who were present on this occasion and the opportunity is being taken, therefore, of reproducing in this issue a photograph (page 54) which was presented a few years ago to The Institution by Mr. C. H. Durrad Lang (Vice-Chairman of the Section in 1905). Any members who were at the first Dinner are asked to get in touch with the Honorary Secretary of the London Students' Section, Mr. K. W. E. Gravett, M.Sc.(Eng.), 85 Seaforth Avenue, New Malden, Surrey, so that a formal invitation may be extended to them to be present at the conversazione next month. Even if a member cannot attend we hope that he will get in touch with the Honorary Secretary, for an attempt is to be made to compile a complete list of those shown in the photograph.

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§M. H. Bower	National Coal Board.
A. A. Fulton	North of Scotland Hydro-Electric Board.
L. T. Hinton, B.Sc.(Eng.)	Radio Industry Council.
F. W. Oakley	Telecommunication Engineering and Manufacturing Association.

With
Eric Davies, B.A., LL.B.

§ Alternate: G. F. Whalley.

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And	*Nominated by*
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M. Landers T. H. Kelsey, M.A. K. F. A. Johnston, B.A. R. Birt, B.Sc.(Eng.)	British Electrical and Allied Manufacturers' Association.
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With
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†C. E. Mills	Fire Offices Committee.
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F. H. Mann	Ministry of Labour and National Service.
R. N. James	Ministry of Supply.
N. Sizer, M.B.E., M.C.	Ministry of Works.
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Major D. A. Andrews	War Office.

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	The Chairman of the Radio Section (*ex officio*).
And	*Nominated by*
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‡C. F. Sutton, M.A.	Air Ministry.
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T. M. H. Stubbs	British Electrical and Allied Manufacturers' Association.
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C. E. Hollingworth, B.Eng. ..	
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D. A. Weale	British Standards Institution.
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R. L. Smith-Rose, D.Sc., Ph.D.	Department of Scientific and Industrial Research.
§Dame Caroline Haslett, D.B.E.	Electrical Association for Women.
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H. W. Grimmitt	Ministry of Fuel and Power.
W. Thomson, B.Sc.	North of Scotland Hydro-Electric Board.
H. Stanesby	Post Office.
*E. M. Lee, B.Sc.	Radio Industry Council.
A. H. Ball	Society of Motor Manufacturers and Traders.

Technical Secretariat:
E. L. E. Pawley, O.B.E., M.Sc.(Eng.)—British Broadcasting Corporation.
C. W. Sowton, B.Sc.—Post Office.
The Secretary of The Institution (or his deputy).

The Radio Interference Committee and Technical Committee ELE/32 (Radio Interference Suppression) of the British Standards Institution have jointly appointed the Sub-Committees listed below. The Chairmen and The Institution's nominees on these Committees are as shown. When concerned with Codes of Practice, the Sub-Committees report also to the Codes of Practice Committee for Electrical Engineering.

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Institution nominees: H. Stanesby; R. T. B. Wynn, C.B.E., M.A.

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JOINT SUB-COMMITTEE ON LIMITS OF RADIO INTERFERENCE
Chairman: Appointment pending.
Institution nominee: The Secretary of The Institution (or his deputy).

JOINT SUB-COMMITTEE ON ABATEMENT OF RADIO INTERFERENCE CAUSED BY DISCHARGE LIGHTING
Chairman: Capt. C. A. Higgins, O.B.E., B.Sc.(Eng.).
Institution nominees: E. M. Lee, B.Sc.; H. Stanesby.

JOINT SECRETARIAT SUB-COMMITTEE (C.I.S.P.R.) ON RADIO INTERFERENCE
Chairman: S. Whitehead, D.Sc., M.A.
Institution nominee: The Secretary of The Institution (or his deputy).

JOINT SUB-COMMITTEE ON CODE OF PRACTICE ON GENERAL ASPECTS OF RADIO INTERFERENCE ABATEMENT
Chairman: E. M. Lee, B.Sc.

* Alternate: A. H. Cooper.
‡ Alternate: C. W. Palmer.
§ Deputy: Miss V. Norvick.

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W. B. Noddings, M.Eng. ..	British Electricity Authority and Area Boards.
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R. M. Muckart	
W. A. Baker	British Non-Ferrous Metals Research Association.
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L. N. Bramley, M.Sc.(Eng.), Ph.D.	Iron and Steel Institute *and* British Iron and Steel Research Association.
F. W. Haywood	Institute of Metals.
O. F. Gullick	Radio Industry Council.
A. T. Kinder	

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P. G. Phelps	Manufacturers of electromedical apparatus.
E. H. Willis	
N. Sizer, M.B.E., M.C. ..	Ministry of Works.
H. S. Souttar, C.B.E.	Royal College of Surgeons.
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Appointment pending	Wiring Regulations Committee.

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G. MacGillivray, A.M.I.Mech.E.
J. G. Richardson, A.M.I.E.E.
Adeniyi Williams, B.Sc., A.M.I.C.E.

Forthcoming Events *at savoy place*

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	**O**	ORDINARY MEETING
Ex	EXTRA MEETING	**R**	RADIO SECTION
I	INFORMAL MEETING	**S**	SUPPLY SECTION
M	MEASUREMENTS SECTION	**U**	UTILIZATION SECTION

1955 — After each paper that has now been published is added the month that its synopsis appeared in the *Journal*.

JANUARY

20 *Thursday*

H. W. WOLFF, B.SC., *and* T. G. F. ATHERTON, B.A. — **U**

"Design, Performance and Application of Miniature Circuit-Breakers" (Paper No. 1745)‖ *Synopsis:* December, 1954

24 *Monday*

CAPTAIN F. J. WYLIE, R.N.(RETD.) — **R**

Informal Lecture on "Radio Aids to Marine Navigation"‡

26 *Wednesday*

E. B. FRANKLIN — **S**

"Sealed Transformers" (Paper No. 1674)‖ *Synopsis:* June, 1954

27 *Thursday*

T. B. D. TERRONI, B.SC.

The Faraday Lecture: "Courier to Carrier in Communications"* (at the Central Hall, Westminster, S.W.1, at 6 p.m. Admission by ticket obtainable from The Institution. A stamped addressed envelope should be sent with the application)

FEBRUARY

1 *Tuesday*

D. EDMUNDSON, B.SC.(ENG.) — **M**

"Electrical and Magnetic Measurements in an Electrical Engineering Factory" (Paper No. 1703)‖ *Synopsis:* September, 1954

A. HOBSON, M.SC.TECH.

"Current Summations with Current Transformers" (Paper No. 1678)‖ *Synopsis:* June, 1954

3 *Thursday*

D. J. BOLTON, M.SC.(ENG.) — **O**

"A Criterion of Distribution Cost" (Paper No. 1739)‖ *Synopsis:* December, 1954

7 *Monday*

C. W. SOWTON, B.SC., will open a discussion on "The Problem of Radio Interference"* — **I**

9 *Wednesday*

J. K. S. JOWETT, B.SC.(ENG.), *and* G. O. EVANS, B.SC. — **R**

"A Study of Commercial Time Lost on Transatlantic Radio Circuits, due to Disturbed Ionospheric Conditions" (Paper No. 1708)‖ *Synopsis:* October, 1954

A. M. HUMBY, C. M. MINNIS, M.SC., F.INST.P., *and* R. J. HITCHCOCK, B.A.

"Performance Characteristics of High-Frequency Radiotelegraph Circuits" (Paper No. 1787)§ *Synopsis:* January, 1955

10 *Thursday*

R. W. PALMER — **Ex**

"Maintenance Principles for Automatic Telephone Exchange Plant" (Paper No. 1777)§ *Synopsis:* January, 1955

14 *Monday*

P. HAMMOND, M.A., will open a discussion on "Teaching Faraday's Law of Electromagnetic Induction"* (at 6 p.m., tea at 5.30 p.m.) — **E**

15 *Tuesday*

W. E. HARRIS — **M**

Informal Lecture on "The Service Engineer at an Atomic Energy Establishment"‡

17 *Thursday*

Short papers evening — **U**

21 *Monday*

COMDR. C. G. FORSBERG, R.N., *and* G. G. MACNEICE, B.SC. — **R**

Informal Lecture on "The Recent Search for and Salvage of the Comet Aircraft near Elba"‡

* No advance information will be available.
‡ A synopsis will be available in advance.
§ This paper will be published not later than 10 days before the date of reading.
‖ This paper has now been published (see page 47).

23	*Wednesday*	A. RUSCK Lecture on "High-Voltage Transmission Developments in Sweden"*	S
24	*Thursday*	Annual Dinner (at Grosvenor House, Park Lane, W.1, at 7 for 7.30 p.m.)	

MARCH

1	*Tuesday*	PROFESSOR F. BRAILSFORD, PH.D., B.SC.(ENG.), *and* C. G. BRADSHAW, B.ENG. "Iron Losses at High Magnetic Flux Densities in Electrical Sheet Metals" (Paper No. 1794)§	M
		C. D. MEE, B.SC., PH.D., *and* R. STREET, M.SC., PH.D. "An Improved Precision Permeameter" (Paper No. 1746) (Published in the *Proceedings*, Part II, December, 1954)	
2	*Wednesday*	E. N. BRAMLEY, M.SC. "Some Aspects of the Rapid Directional Fluctuations of Short Radio Waves reflected at the Ionosphere" (Paper No. 1713)‖ *Synopsis:* August, 1954	R
		E. N. BRAMLEY, M.SC. "Some Comparative Directional Measurements on Short Radio Waves over Different Transmission Paths" (Paper No. 1716)‖ *Synopsis:* September, 1954	
		W. C. BAIN, M.A., B.SC., PH.D. "On the Rapidity of Fluctuations in Continuous-Wave Radio Bearings at High Frequencies" (Paper No. 1715)‖ *Synopsis:* October, 1954	
3	*Thursday*	G. L. E. METZ "The Electrical Engineering Industry in the Post-War Economy—II" (Paper No. 1795)§	O
7	*Monday*	C. M. COCK will open a discussion on "What is the Future of the Steam Locomotive?"*	I
9	*Wednesday*	P. E. AXON, O.B.E., M.SC., PH.D., C. L. S. GILFORD, M.SC., *and* D. E. L. SHORTER, B.SC.(ENG.) "Artificial Reverberation" (Paper No. 1796)§	R
10	*Thursday*	F. W. ROBERTS, B.SC.(ENG.) "The Electrical Equipment of the Toronto Subway Cars" (Paper No. 1754)‖ *Synopsis:* October, 1954	Ex
15	*Tuesday*	J. C. WEST, B.SC., PH.D., *and* J. L. DOUCE, M.SC. "The Mechanism of Sub-harmonic Generation in a Feedback System" (Paper No. 1693)‖ *Synopsis:* July, 1954	M
		J. C. WEST, B.SC., PH.D., *and* P. N. NIKIFORUK, B.SC. "The Transient Behaviour of Remote-Position-Control Systems with Hard-Spring Non-Linear Characteristics" (Paper No. 1728)‖ *Synopsis:* October, 1954	
16	*Wednesday*	R. T. RUSHALL *and* J. S. SIMONS, B.SC.(ENG.) "An Examination of High-Voltage D.C. Testing applied to Large Stator Windings" (Paper No. 1771)‖ *Synopsis:* January, 1955	
17	*Thursday*	A. O. JOHNSON, B.SC.TECH., *and* N. F. MARSH, M.A. "The Standardization of Retail Electricity Tariffs" (Paper No. 1798)§	U and S
21	*Monday*	R. O. JENKINS, PH.D., will open a discussion on "Materials for Valves"†	R
22	*Tuesday*	T. SIKLOS, DIPL.ING., will open a discussion on "High-Voltage Equipment in Colleges"* (at 6 p.m., tea at 5.30 p.m.)	E
22	*Tuesday*	Section Dinner-Dance (at the Café Royal at 7 for 7.30 p.m.)	S
23	*Wednesday*	J. CHRISTIE, H. LEYBURN, B.SC.(ENG.), *and* J. F. BIRD, M.C., T.D., B.SC. "Proving the Performance of Circuit-Breakers, with particular reference to those of Large Breaking Capacity" (Paper No. 1707)‖ *Synopsis:* August, 1954	S
		J. CHRISTIE, H. LEYBURN, B.SC.(ENG.), *and* R. W. FENN, M.ENG. "A New Testing Station for High-Power Circuit-Breakers" (Paper No. 1736)‖ *Synopsis:* December, 1954	
30	*Wednesday*	Radio and Measurements Sections Dinner-Dance (at the Café Royal at 7 for 7.30 p.m.)	R and M
31	*Thursday*	E. W. GOLDING, M.SC.TECH. "Electrical Energy from the Wind" (Paper No. 1727)‖ *Synopsis:* December, 1954	O

* No advance information will be available.
† An abstract of the introduction will be available in advance.
‡ A synopsis will be available in advance.

§ This paper will be published not later than 10 days before the date of reading.
‖ This paper has now been published (see page 47).

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C. W. OATLEY, M.A., M.SC.
January 1955 — **Radio Section: Chairman's Address**

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M. M. Z. EL-KHARADLY, B.SC., PH.D.
January 1955 — **Some Experiments on Artificial Dielectrics at Centimetre Wavelengths** (PAPER NO. 1700)

R. I. PRIMICH, PH.D., B.SC.
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S. E. YUSSUF, PH.D., AND PROFESSOR J. C. PRESCOTT, D.ENG.
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